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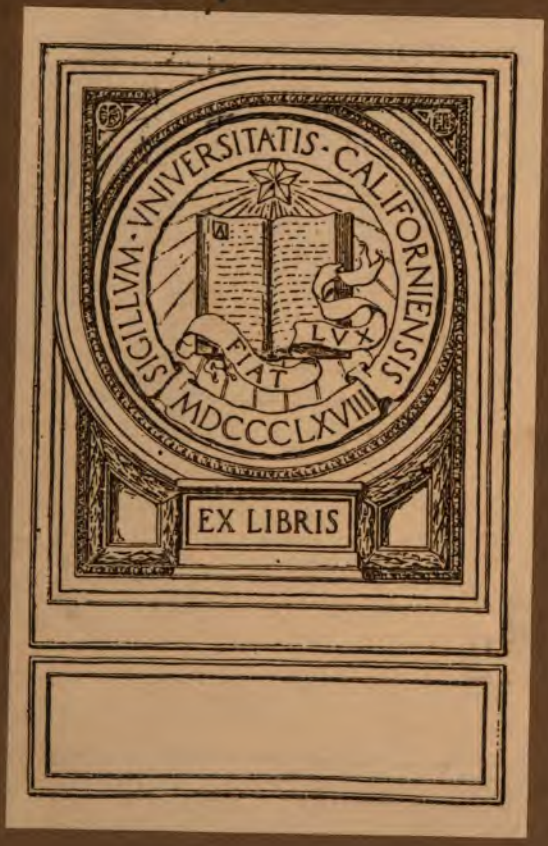
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A Miniature Tank Locomotive.

Gauge, 10½ inches; Scale, 2 inches to the foot. Built from a design by the Author.

For description] [*see page* 274.

THE
MODEL LOCOMOTIVE.

ITS DESIGN AND CONSTRUCTION

A Practical Manual on the Building and Management of Miniature Railway Engines

BY

HENRY GREENLY

Containing 370 *Illustrations and* 9 *Folding Plates*

LONDON
PERCIVAL MARSHALL & CO.
26-29 POPPIN'S COURT, FLEET STREET, E.C.
1904

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AUTHOR'S PREFACE

In submitting this volume to the general reader a word or two in explanation of its objects and scope is perhaps necessary. The book deals primarily with *working* model locomotives in all sizes, and, for the most part, with those built for the instruction and amusement of their owners, both during the making and afterwards. I have endeavoured to treat the subject thoroughly, and although I fear I have not altogether exhausted the possibilities of miniature locomotive construction, it is to be hoped that the details and component parts severally described will enable the reader to design and build any type of locomotive model to any desired scale. The book is the only one of its kind, and may also be recommended to the model engineer who does not exclusively go in for locomotive work. As model railway engines in the larger sizes may be made to serve commercial ends, several detailed drawings and two designs of engines of this class are included.

I have to thank Mr A. G. Robins, M.I.M.E., for the photograph on page 10, and Mr Percival Marshall, A.I.M.E., the editor of *The Model Engineer*, for permission to use many of the illustrations contained herein. Several of the designs which I have from time to time prepared for various model-making firms are reproduced, notably the model Midland locomotive and details for Messrs W. J. Bassett Lowke & Co. of Northampton; the L.T. & S.R. design for W. Martin & Co. of West Ham, E.; the L.N.W.R. tank locomotive for Stuart Turner of Shiplake-on-Thames; and the G.W.R. tank engine and the engine depicted on the frontispiece, built by Flooks & Smithies of Watford, castings of which they respectively supply.

I must also acknowledge my indebtedness to Mr H. H. Harrison, Mr D. C. Glen, M.I.M.E., Mr E. D. Löwy, and others, for the help they have afforded me in various directions.

HENRY GREENLY.

London, E.C.

180700

INTRODUCTORY NOTE

BY W. J. TENNANT, A.M.I.M.E.

BUILDERS of model locomotives are so frequently asked in conversation the prefatory question, "Of what *utility* are your models?" that a justification of their value seems to the writer to be a pardonable prelude for Mr Greenly's book. It may at once be conceded that the evil-smelling, dribbling, ten-and-sixpenny model of the type familiar to generations of schoolboys is of use only to such extent as it may serve to encourage in its proud possessor a possibly useful sympathy with things mechanical. The real utility of the model begins for the amateur mechanic when its construction induces him to exercise and improve his craftsmanship and to cultivate an interest in modern locomotive engineering.

For the novice engaged in practical engineering work as an engineer student or as an apprentice, a model manifests its utility by making him view locomotive design as a whole. In the foreground of his daily life the detail of engineering is so prominent, and therefore bulks so large in the view, as to tend to obscure the broader aspects of engine design with which, among other matters, the beginner should be preparing himself to deal; and it is in the production of models, and particularly in the production of working models, that he may usefully be led to think intelligently upon problems of the kind that his chiefs have to solve, and that he himself will have to grapple with if in due time the mantle of responsibility descends upon him. Incidentally, the young professional will probably find that model-building will bring him into touch with the non-professional amateur, and if he attains to any considerable degree of familiarity with amateur work he will be likely to receive a salutary stimulus from observation of the

surprising quantity and excellence of a large proportion thereof; this will assuredly be useful to him, and it will be likely to lead both amateur and professional to properly appreciate, and maybe to worthily imitate, the work of such men as the gifted brothers Coates and other skilful model-makers whose productions are treasured in the unrivalled collections to be found in the southern galleries of the Victoria and Albert Museum, the Mecca of the amateur of engineering.

Coming now to the trade, ready-made model locomotives have been greatly cheapened in cost and improved in design and construction within the last few years; this improvement is largely due, it is suggested, to *The Model Engineer* journal and to the Society of Model Engineers, with both of which our author has been honourably connected for some time past. A great deal of exceptional experience has been afforded him in this connection as a designer of locomotive models of all sizes, from commercially-valuable engines of 7 cwt., downward, and is recorded in the following well-illustrated pages, in which many useful and interesting evidences of originality, neatness and ingenuity of design and unique completeness of treatment will be found, together with a regard for elegance of externals which is admirable.

That the proportions of a successful working model are not obtainable by slavish reduction of the scale of its prototype is made clear in this volume, which lays down very plainly the lines along which success may reasonably be sought, and thereby would seem to well justify its existence. Attention is particularly directed to Chapter III., on "The Principles of Locomotive Design," and Chapter IV., on "Boiler Design."

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THE MODEL LOCOMOTIVE

ITS DESIGN AND CONSTRUCTION

CHAPTER I.

INTRODUCTION.

THAT the miniature locomotive is one of the most popular

ERRATA.

Page 21. Under illustration, *read* $\frac{5}{32}$, *not* $\frac{1}{8}$.

Page 50. Sixth line from bottom, *read* $\frac{5}{32}$, *not* $\frac{1}{8}$.

supply the reader not only with fully-worked-out designs for models of various scales and types, but to include more or less standard details of boilers, machinery, and superstructures, together with rules and formulæ, all of which have a practical basis, so that without the expenditure of valuable time in trial experiments ultimate success may be assured.

Where a beginner is anxious to try his hand at a working model locomotive, the writer would urge him not to be too ambitious, and,

in preference to taking a design involving an immense amount of work, to attempt quite a simple engine.

If circumstances dictate, and there is a likelihood of the construction proceeding without insuperable difficulties, the reader may confidently rely on the rules and drawings herein given; and where these are carefully adhered to, failure should not occur.

Model engineers approach the construction of a miniature locomotive from many different points of view. Some care not one whit whether the model they are making will turn out a practical efficient steam-engine, the construction to a given scale being the principal pleasure they derive from the task.

Others love to see the model careering round a track, and to this end make an engine with the exterior to scale, sometimes, but not always, copying some well-known prototype, cutting down and simplifying the working parts to the minimum.

There are, of course, a large majority who combine the two objects, and it is in the model-maker requiring information on the subject of the design of the working model locomotive that the writer is more especially interested.

In stating that a *successful* model locomotive is desired there are, of course, measures of success and different results to be aimed at; however, throughout this work the designs should result in the reader obtaining engines which shall be capable of running *continuously* with fairly heavy loads.

The history of the working model locomotive would be difficult to trace. No doubt, ever since the railway locomotive 'came to stay,' models have been built in out-of-the-way places; but whence came the 'Ajax' type of model locomotive or the 'magnificent slide valve express' engine upon which many youthful hopes have been laid, has yet to be discovered.

Amongst the miniature locomotives of note made in the early days of steam transport on land, the model shown in fig. 1 is a very good example.

Sometimes scale replicas are made to serve historical and educational purposes, and the number of models in museums and private collections (all over Europe) is very large. However, this work will not describe the construction of such models, which, it may be mentioned, are generally made by skilled workmen to

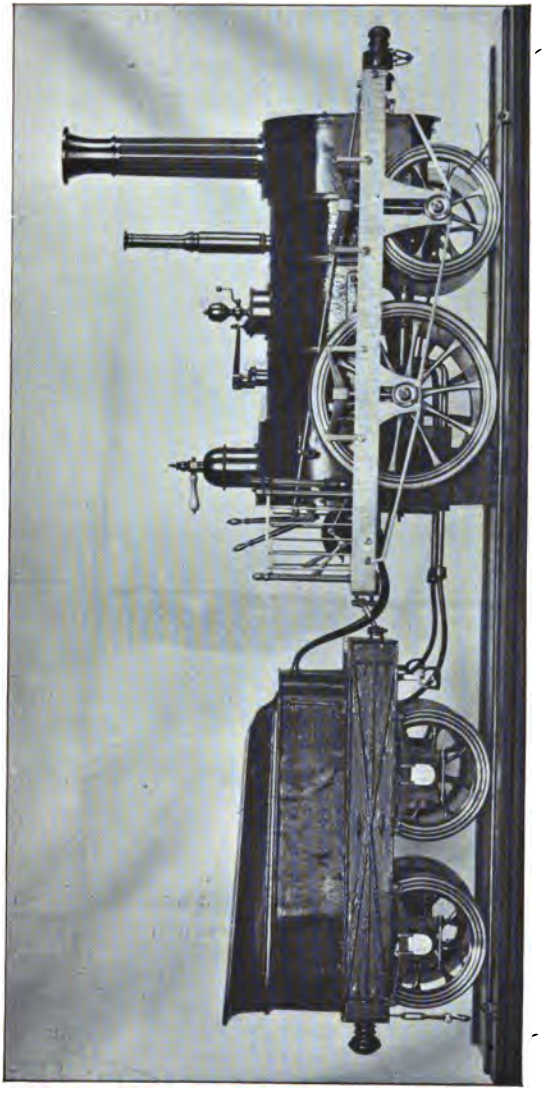


Fig. 1.—A 1-in. Scale Model of an early Liverpool and Manchester Railway Locomotive (1830–1833).

(Now in the possession of Mr Ernest D. Löwy.)

the working drawings of the original and without any great regard to cost.

THE CHOICE OF SCALE AND GAUGE.

The sizes of the locomotives with which it is proposed to deal within these pages will be to a large degree limited to those built for the amusement of their several owners. Some of the designs

Fig. 2.—THE DUKE OF WESTMINSTER'S LIGHT LOCOMOTIVE.
Gauge, 15 in. Maximum speed, 20 miles an hour.

will be of such proportions as to render the finished machines capable of really useful work for exhibition or estate purposes.

The Duke of Westminster some years ago built a miniature railway of 1 ft. 3 in. gauge on his estate at Eaton Hall, which not only serves to interest the visitors to his house, but has proved a commercial success, connecting as it does the residence with the neighbouring main line of railway, and saving a considerable amount on the previous annual expense of carting.

The 2-in. scale engine illustrated by the frontispiece is intended for exhibition purposes, to pull two or three dozen school-children

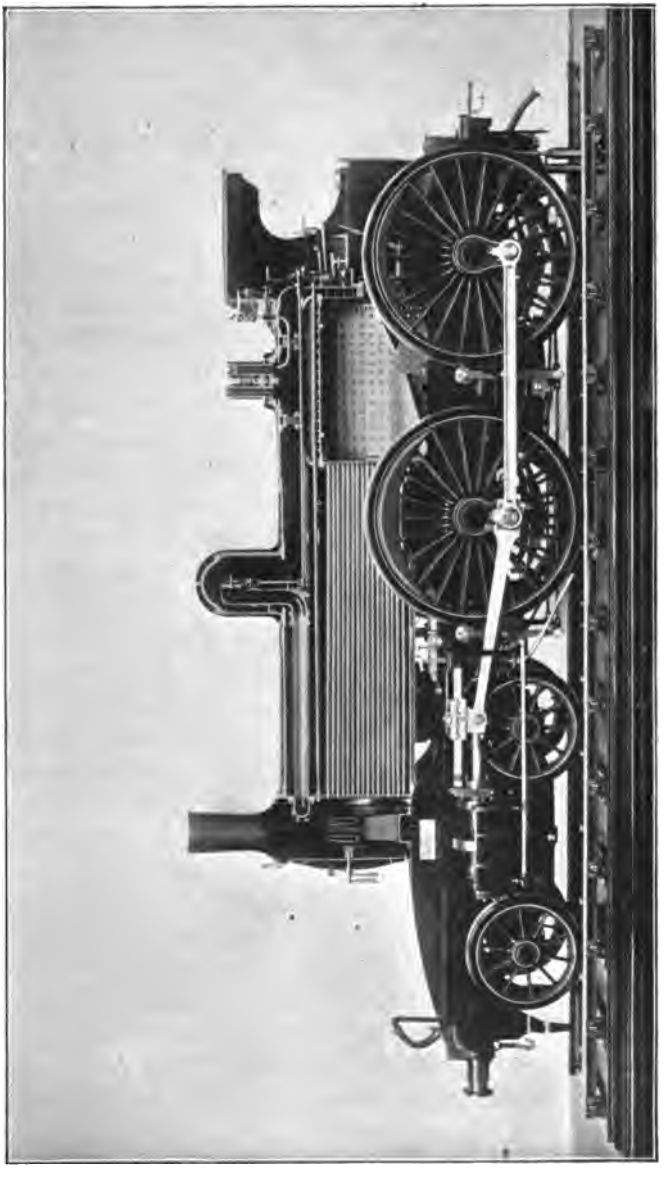


Fig. 3.—Sectional Model of Express Locomotive, London and South-Western Railway.
(Now in Machinery Section, South Kensington Museum.)
Scale of Model, 1½ in. to the foot.

at a 'treat' ground, and to some extent take the place of the time-honoured roundabouts, donkey-rides, and swings.

With no previous experience to guide him, the model locomotive builder is not advised to go in for an elaborate engine of a scale under ½ in. to the foot. This and smaller scales are more suitable for the simplest of designs. A model express engine to this scale will measure some 25 to 30 inches long and weigh from 18 to 25 lbs. With a very free wheel-base, curves of 4 ft. radius may be negotiated, but the writer does not advise less than a 5 ft. radius. $\frac{3}{16}$-in. scale is a very good one to adopt for those with limited space and tools. They will find an engine of this size present no great difficulties in manufacture, and at the same time be small, portable, and comparatively efficient as a working steam-engine. The minimum radius should be about 6 ft. Five-eighths-inch scale is another excellent scale for small models. Really powerful models capable of pulling a boy of eight or ten years of age may be constructed to this scale; and if a small four-wheeled engine is built, the minimum radius of curve which may be traversed will work out to about 5 ft. For larger engines the minimum radius should be 7 or 8 ft.; indeed, it may be said generally that the small types of engines, owing to the shorter wheel-base, will run on curves of 75 per cent. of the minimum radius necessary for express engines.

A ¾-in. scale renders it possible to model a locomotive very closely to scale as regards the machinery and at the same time to preserve the working qualities. It is a rather large scale in some respects, but although enough power can be obtained, it is not possible to design a suitable engine behind which one may conveniently ride. Curves should never be less than 10 ft. radius. 15 ft. is a better figure, and should lessen the number of derailments, as models of ¾-in. scale often attain speeds of ten miles an hour, and, having no one on the footplate, may easily get out of control. One-inch scale produces another 'in between size'—that is, regarding it as a useful scale for working models; however, it is one which allows the manufacture of a *really scale* model, and can be recommended for historical and exhibition engines. 1¼ inch to the foot is the smallest scale giving an engine which may be ridden upon conveniently; and its adoption is to be recommended to those who wish to construct a locomotive of the

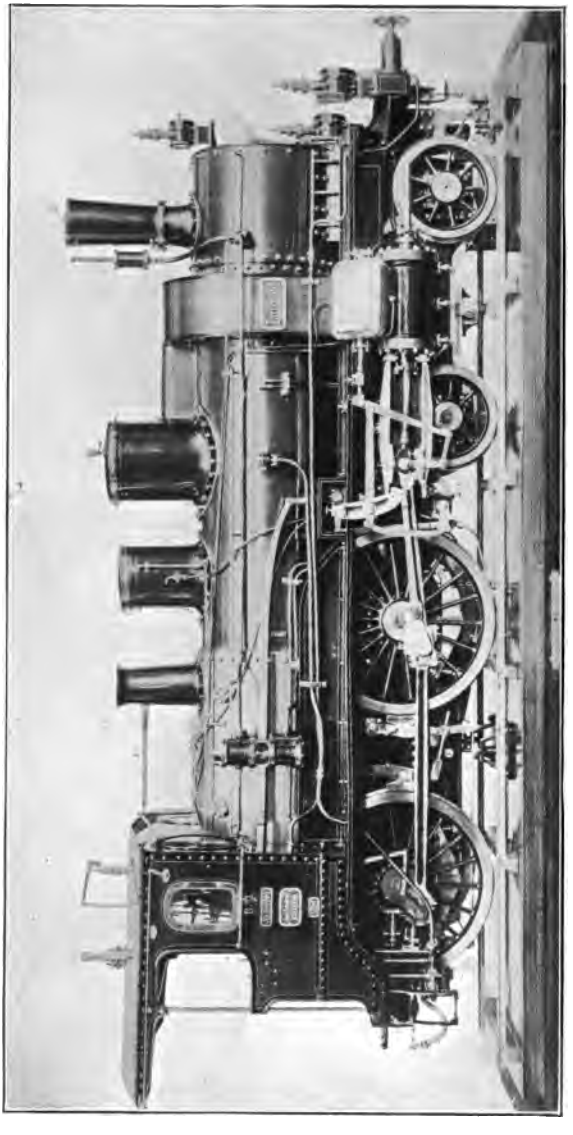


Fig. 4.—A Model Bavarian State Railway Locomotive, made by a Nuremberg model-maker for exhibition at Paris in 1900.

smallest dimensions and of sufficient power to carry one person at least, at a high speed continuously.

One-and-a-half inch scale is suitable for those who wish a little larger engine. Speeds of fifteen miles an hour with three passengers behind such a model may be attained with ease.

Two-in. scale is the smallest size advisable where the engine is to be really useful and of commercial value. A total load of one ton (including engine) should be within the capabilities of a really well-designed and built 2-in. scale model locomotive. Steel

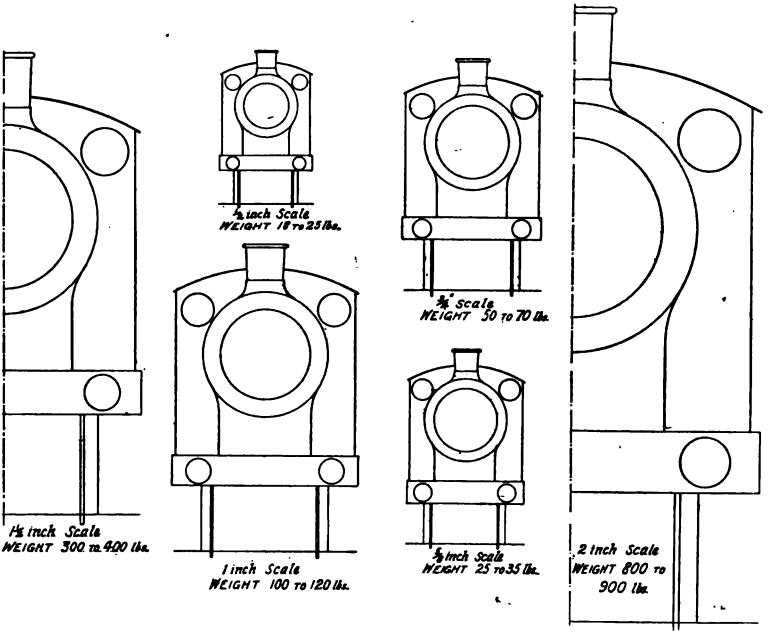


Fig. 5.—Relative Sizes and Weights of Model Express Locomotives.

boilers may be used, and the cost of such an engine should not be excessive. Fig. 5 gives a good idea of the differences in the sizes of model locomotives, and also indicates the probable weight of express engines built to the respective scales.

The next point that requires attention is the question of gauge. The interesting correspondence in *The Model Engineer* (vol. ix., 1903) on this subject shows the diversity of opinion that exists in settling the gauge of railway for a given scale of model,

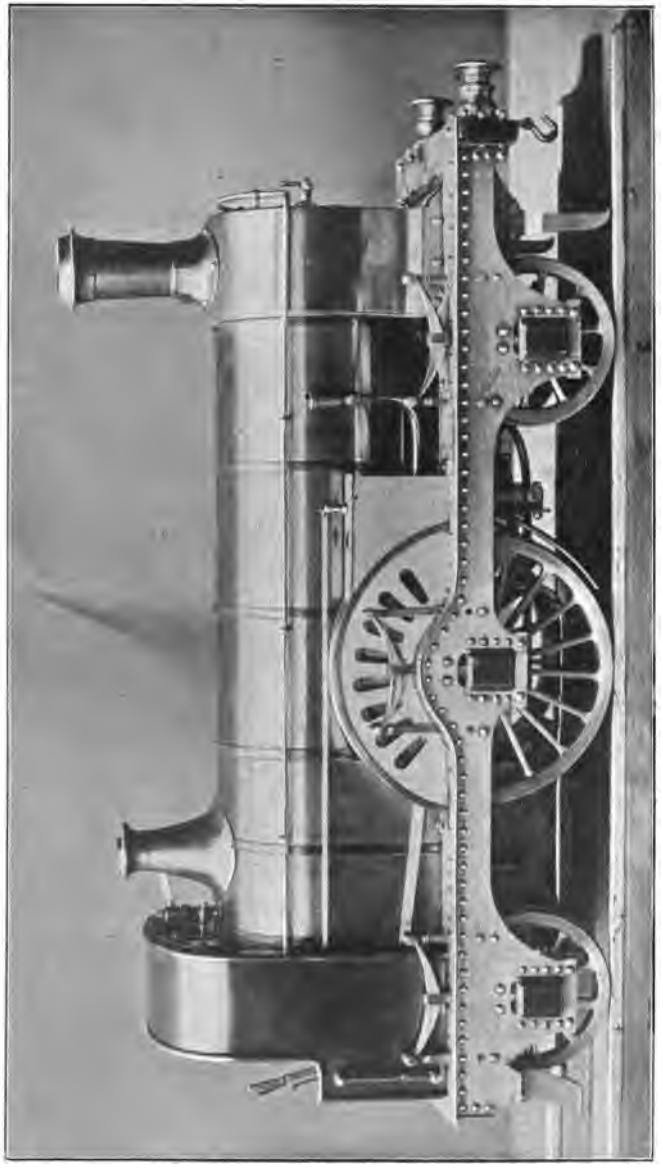


Fig. 6.—A ¾-in. Scale Model of an Old Great Northern Railway Single-wheeler.

(Now in the possession of Mr E. D. Löwy.)

Photo by] [*Waller Martin.*

and the difficulties of arriving at a definite standard gauge for the model locomotive are greatly increased by the fact that the circumstances are not invariably alike.

George Stephenson's advice to the south-country railway engineers at a time when isolated lines of railway were under construction was to make the gauge the same as in the north, saying that they were then a long way apart, but some day would be joined—a prophecy which, as we all know, has been fulfilled to its utmost. This cannot be acted upon for the reason of the varying sizes of models. However, differences in gauge for given scales, which some model-makers may imagine tides them over otherwise insuperable difficulties, are to be deprecated, and the writer can only recommend that such alterations be made where a large number of models have been made to a gauge which is not a scale equivalent of the English standard of 4 ft. 8½ in. between the rails.

Some model loco builders favour a considerably increased gauge, from the point of view that the cylinder bore of an inside-cylindered model is very much limited if the standard gauge is adhered to. Whilst to a slight extent this is true, it is not the greatest obstacle in model locomotive design, and can be surmounted in exactly the same way as in the real engine by placing the valve chest on top or below the cylinders.

The real trouble in small scale ($\frac{1}{2}$ and $\frac{9}{16}$ in.) inside-cylinder model locomotives *with link-motion*, is in the matter of the crank axle. Sufficient room has to be found for the four webs and eccentrics, and, to make a really serviceable job, widening seems necessary. However, the writer does not advise link-motion in such small locomotive models, and therefore this difficulty is mitigated.

In $\frac{5}{8}$-in. scale engines the firebox is the chief difficulty. Unless some method of increasing the width of the inner box is adopted, the use of a silent 'Primus' burner is impossible, the maximum distance between frames being about 2½ in.; and the firebox, if placed in the orthodox manner, cannot be wider than 1⅞, the greatest amount of squeezing in of the No. 4 burner bringing it to somewhere about $2\frac{1}{16}$ in. wide; such cannot be employed. In the writer's opinion a little widening is an advantage, but should not

be carried to an extent that makes it immediately apparent. The widening of the rail gauge is also less noticeable in an inside-cylindered engine (if the footplate width is also slightly increased) than in an outside-cylindered engine, as the cylinders have not only to be extended to the amount of the excess of gauge, but very often to meet the practical considerations of design in addition, these considerations being independent of the gauge altogether. The exception to this is the G.N.R. singles and other large-wheeled engines having low-pitched boilers.

There are two other points which must be considered, and they are as follows:—

(1) If the standard English gauge of rails is adhered to exactly in reducing to model sizes, then other parts are more often than not thrown out of scale, generally with an encroachment on the available width for the machinery.

For instance, take the suggested $2\frac{3}{8}$-in. gauge for $\frac{1}{2}$-in. scale locomotives. The distance between the tyres, which is just as much a standard[1] in the railwayman's eye as that between the rails, would, if the engine is to be a practical working model, work out to about $2\frac{1}{8}$ in., which is less than the scale equivalent of 4 ft. $5\frac{1}{2}$ in. (the dimension just referred to), viz., $2\frac{7}{32}$ in. (fig. 7). Therefore, judging by the majority of $\frac{1}{2}$-in. scale models built, which run on a rail gauge of $2\frac{1}{2}$ in., scale advocates cannot complain if the writer advises that the scale distance between tyres be the ruling dimension for this scale at least; indeed, he is of opinion that this method is one which should be adopted for all scales. If not, then working from the proposed $2\frac{3}{8}$-in. gauge, a model G.N.R. 8 ft. single will have to be provided with a boiler much smaller than scale, even if the outer lagging is dispensed with, the width between the driving wheels being the limiting dimension as regards the diameter of the boiler barrel; and instead of a boiler measuring the scale equivalent of 4 ft. 4 in. outside the lagging horizontally, the diameter will have to be about 2 in.

Fig. 8 gives a good idea of what happens in modelling to $\frac{3}{4}$-in. scale. A $3\frac{1}{2}$-in. gauge is the standard gauge of the Society of Model Engineers, nominally, the rails being laid $3\frac{17}{32}$ in. (the correct scale

[1] The only variation is in driving wheel tyres and in carriages, which have thinner flanges, for reasons which would take too long to explain here.

equivalent) between, in actual practice. It will be seen that it is necessary to encroach upon the distance between the tyres where sufficient play between flange and rail and thickness of flange are provided, and note should be taken that in all cases—to a less degree in larger engines—a gauge correctly to scale reacts on the all-important distance between tyres.

Another way of fixing the gauge would be to start from the boiler, arranging this to scale, and letting the width between rails come what it will.

The remaining point is :—

(2) That those with limited space for curves will not find salvation by building models of express engines to small scales, such as $\frac{3}{8}$-in. or $\frac{1}{2}$-in., but with the adoption of medium scales; for instance, $\frac{9}{16}$, $\frac{5}{8}$, and, perhaps, $\frac{3}{4}$-in., smaller types of locomotives being modelled.

With reference to this matter, it often has to be pointed out that a $\frac{5}{8}$-in. scale four-wheeled (or six-wheeled engine, one pair of wheels being on a pony truck) will be found infinitely better on such sharp curves as those of 4 to 5 ft. radii than, say, a model G.N.R. 'Atlantic' or Caledonian Railway 'Dunalastair,' although with the latter types much can be done in the way of modifying the prototypes by fitting small bogie wheels, pony trucks, and cutting away the main frames.

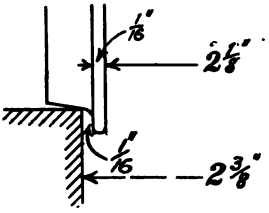


Fig. 7.—Widths of $\frac{1}{2}$-in. Scale Loco to $2\frac{3}{8}$-in. Gauge.

As previously mentioned, some favour a very wide gauge, but the writer must point out that a strict adherence to this policy will give an ugly, disproportionate engine, and although he has seen several good-looking models made on this principle, the most important features have been so proportioned as to really alter the scale, and instead of having a $\frac{1}{2}$-in. scale locomotive built to a $2\frac{3}{4}$ or $2\frac{7}{8}$-in. gauge, the model has, in its general dimensions, become a $\frac{9}{16}$-in. scale engine, and therefore has the correct gauge of this scale—in fact, is more or less of the standard proportions.

Other modellers take the opposite course, and if they have long since fixed the gauge and are possessed of valuable rolling stock

and other models suited to that gauge, it would be a pity to have to render these latter useless by altering the gauge when more powerful engines are required.

The Cape Government standard gauge of 3 ft. 6 in.—the Society's gauge of 3½ in. being used—renders it possible to use locomotives of 1-in. scale. The writer would, however, recommend that if this course be adopted, C.G. Railway types of locomotives should be copied.

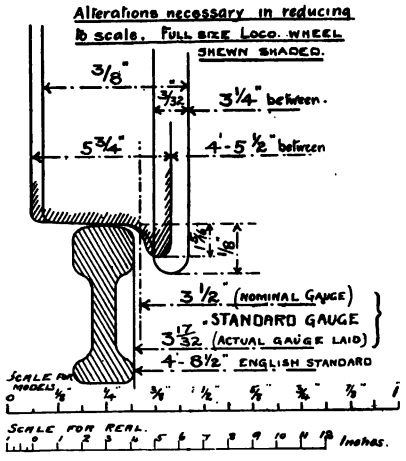


Fig. 8.—Relative Sizes of Real and Working Model Tyres to ⅜ in. to the Foot.

An increase of scale and gauge does not always increase the price of a properly-made model locomotive in direct proportion. A reference to the catalogues of any good firm of model locomotive builders will show that the ⅜-in. scale model will cost on the average one-half the price of a 2½-in. gauge engine, and the prices of a ½-in. scale model and a $\frac{9}{16}$-in. scale are also in the ratio of 1 to 2. Therefore, the author can again advise small types of engines of moderate gauges instead of tiny express engines, wherever cost must be kept low, and at the same time a powerful locomotive obtained.

To reduce size, cost, and the radii of the curves of the railway, prototypes may with advantage be chosen from the famous G.W.R. broad-gauge locomotives. This not only fulfils the above recommendation, but the express passenger engine may be modelled, and for a 3½-in. gauge engine such a locomotive should be very short and portable.

Returning to the recommendation of George Stephenson, seeing that there are several gauges in common use, adherence to those already fixed may be advised.

The small gauges are respectively termed 1¼ in. (No. 0 gauge), 1¾ in. (No. 1 gauge), 2 in. (No. 2 gauge), 2½ in. (No. 3 gauge), and

3 in. (No. 4 gauge) in model locomotive catalogues. The last-named gauge, however, is not 3 in., but $2\frac{25}{32}$ between the rails. These standard gauges are used for $\frac{1}{4}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, and $\frac{9}{16}$-in. scale models, respectively.

There appears to be a wide difference in the gauges employed for $\frac{5}{8}$-in. scale model locomotives; but as far as can be discovered there are several $3\frac{1}{4}$-in. gauge $\frac{5}{8}$-in. scale locomotives in the possession of the members of the S.M.E., and one or two prominent firms have also supplied engines and fitted up several railways to the same gauge. Considering, therefore, the diversity that exists in some quarters, there should be no hesitation in recommending the amateur who cannot afford to build a $\frac{3}{4}$-in. or 1-in. scale locomotive, to lay his railway to this dimension. The distance between the tyres should be 3 in., which only exceeds the scale dimension by about $\frac{7}{32}$ in., and the widening is not in any way noticeable in the finished engine. Its advantages, chiefly in the matter of burner arrangements and crank-shaft dimensions, are many.

For $\frac{3}{4}$-in. scale model, $3\frac{1}{2}$-in. gauge (laid $3\frac{17}{32}$ or $3\frac{9}{16}$) should be employed, and the writer cannot see his way clear to advise anyone to alter that gauge either way. A $4\frac{1}{2}$-in. gauge is used by some, and would appear to be a good gauge for a $\frac{7}{8}$-in. scale locomotive. One-inch scale locomotives have in the past been made largely to 5-in. gauge (instead of $4\frac{3}{4}$ in., the round figure for the scale equivalent of the standard English measurement); but this is largely due to the G.N.R. 8-ft. single-wheeler having been the most popular type of this scale, the methods hinted at earlier in this chapter of keeping the boiler to scale and letting the rail gauge come what it will, being used. However, the consensus of opinion appears to be that the distance between tyres should be kept to scale—viz., $4\frac{1}{2}$ in. (bare), the gauge being $4\frac{3}{4}$ in. (or $4\frac{13}{16}$ in. laid).

From what the writer can gather, $1\frac{1}{4}$-in. scale locomotives are in a larger number built to gauges of 6 in. and $1\frac{1}{2}$-in. scale to $7\frac{1}{4}$ in. Two-inch scale engines, following Mr. Holder's (the Pitmaston Moor Green Railway) practice, are in all cases of which definite information is to hand, built to a $10\frac{1}{4}$-in. rail gauge, the distance between tyres being $9\frac{5}{8}$-in. The next popular

gauge is 15 in. As to the loading gauge, the author would always advise the standard British one — that is, for models designed on the 'free lance' principle, *which in their main features follow the practice of locomotive engineers of this country* (see fig. 9).

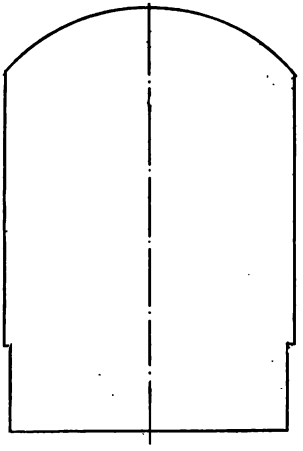


Fig. 9.—Maximum Loading Gauge used by British Railways.

(*Scale,* $\frac{5}{32}$ *in. to the foot.*)

CHAPTER II.

Locomotive Types.

The model locomotive builder, before he commences the preparation of the working drawings for his prospective engine, should acquaint himself with leading features of the now numerous types of locomotives used on our great railways, and even where his mind is already made up by a particular fancy for any given class of engine, the inherent advantages and disadvantages of the chosen design with respect to the rendering in miniature should be carefully considered.

The following outline drawings, together with the description of the possibilities of the several types comprised therein, are intended to help in this direction. The sketches are to uniform scale of $\frac{1}{8}$ in. to the foot, and where drawings of actual locomotives are not given, designs have been made with an eye to the requirements of the model more especially.

Locomotive types may be classified generally under two heads:

Tender Engines, having a separate carriage for fuel and water; and

Tank Engines, being self-contained locomotives with water tanks and fuel bunkers all on the one frame.

Tender engines are used for long distance trains, and tank engines for local passenger, goods, and shunting purposes.

There are passenger engines, goods engines and shunting engines, but these classifications depend largely upon the size of the railway company owning them. For instance, a locomotive used solely for shunting operations by a large company would be employed for passenger work on a very small railway or on a country branch of a railway of moderate size.

We also have passenger tank engines, goods tanks, both tender passenger and goods engines, and also engines suitable for either class of work. Shunting engines are never provided with a tender.

The majority of locomotives employed on express passenger trains consist of the type known as 'four wheels coupled bogie express'

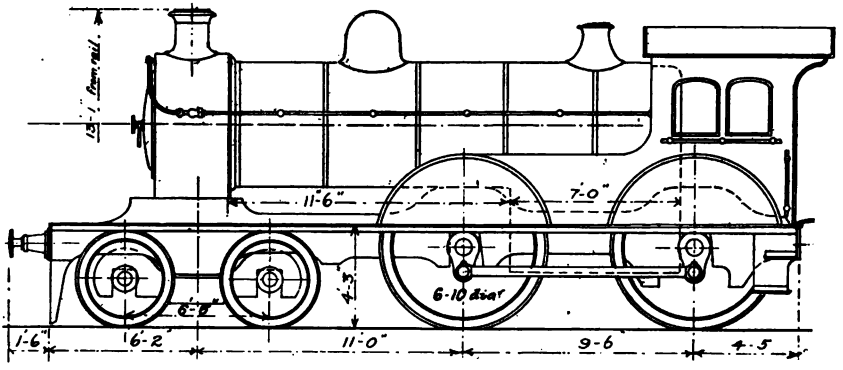


Fig. 10.—North-Eastern Railway, No. 2015.

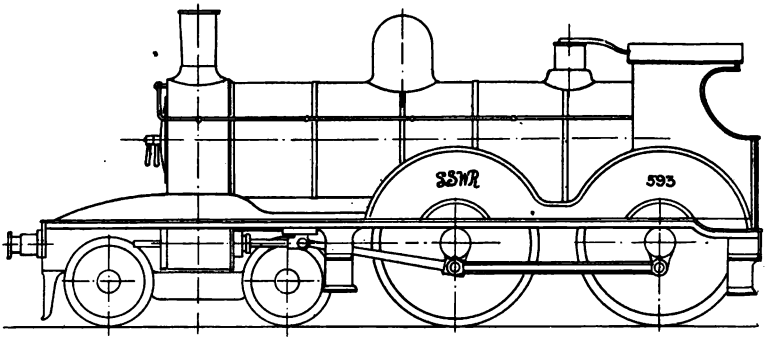


Fig. 11.—London and South-Western Railway Outside-Cylinder Locomotives.

engines. Fig. 10 illustrates the No. 2015 class on the North-Eastern Railway.

The cylinders and frames are inside and the bogie is at the leading end, a six-wheel tender of the usual British standard pattern (fig. 337, p. 235) being attached.

A variation of this design is the outside-cylinder engine No. 593 on the L. & S.W.R., as illustrated by fig. 11, a type

almost universal in American practice until quite recently (see fig. 12A).

The chief objection to both of these kinds as regards their possibilities in model work is the fact that the firebox is limited by the distance between the coupled wheels. This is not, however, so

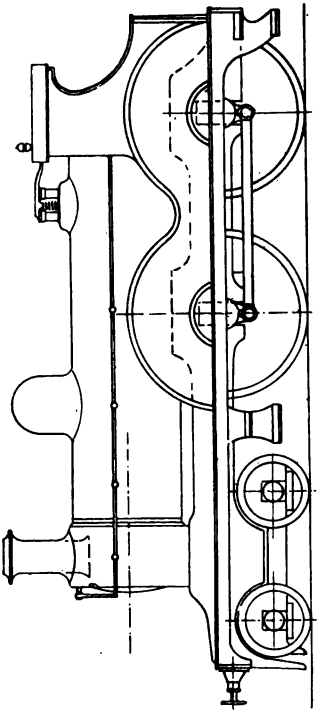


FIG. 12.—LANCASHIRE AND YORKSHIRE RAILWAY 7 FT. 3 IN. FOUR-COUPLED LOCOMOTIVE.

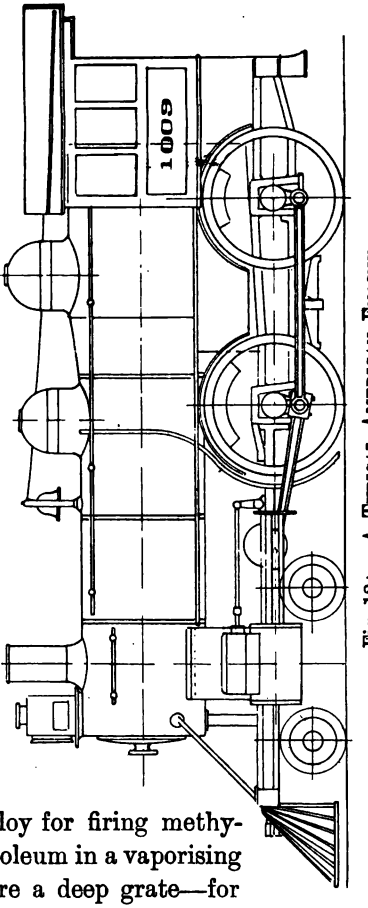


FIG. 12A.—A TYPICAL AMERICAN ENGINE.

detrimental in the case of small model locomotives (1-in. scale and under), which as a rule employ for firing methylated spirit in a wick lamp or petroleum in a vaporising burner, as in larger engines where a deep grate—for burning solid fuel—is essential. The smaller model may be provided with a shallow firebox, and this can then be extended backwards over the trailing axle.

Another drawback to both types is that the bogie wheels are generally of fairly large diameter, and if the model is built to scale

the engine will only run on a curve of comparatively large radius. This can be got over by reducing the bogie wheels to the scale equivalent of a diameter of about 3 ft. (see L. & Y.R. four-coupled

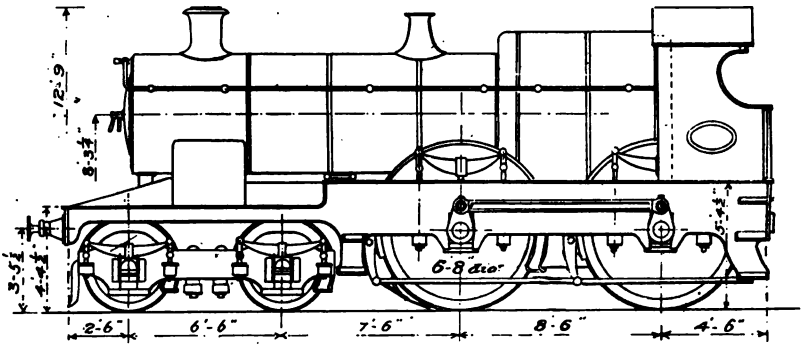


Fig. 13.—Great Western Railway 'Atbara' Class.

bogie locomotive No. 1012 class, fig. 12, which has bogie wheels of these dimensions). It will then usually be possible to cut away the main frames to allow both leading and trailing wheels of the bogie to pass under them and at the same time to clear the valve

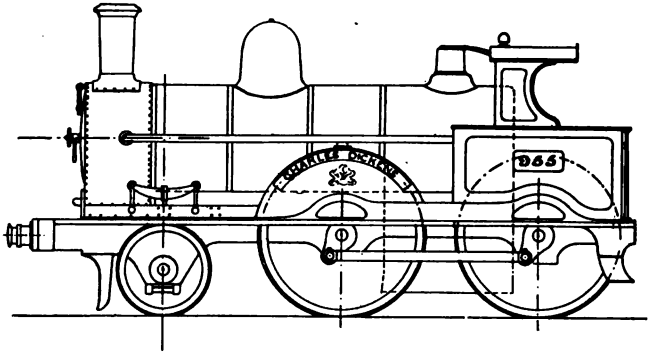


Fig. 14.—London and North-Western Railway Locomotive 'Charles Dickens.'

spindle and piston cross-heads in the outside cylinder types. American locomotives are generally designed with small bogie wheels. Outside framed engines such as the G.W.R. 'Atbara' class get over these difficulties to a great extent.

The four-coupled bogie engine was the outcome of an older and still more English type of engine, the four-coupled six-wheeled locomotive with the carrying wheels leading. The carrying wheel

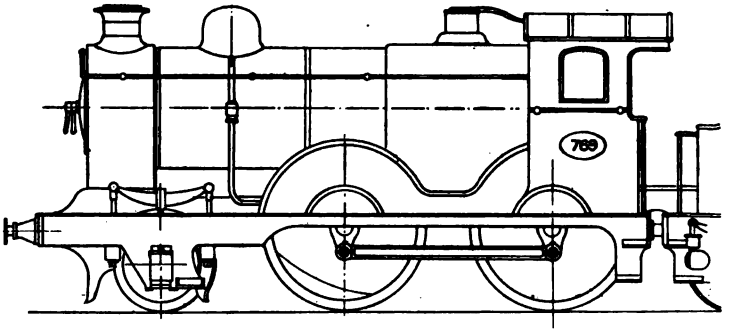


Fig. 15.—Great Eastern Railway Rebuilt '760' Class.

in this type is often provided with radial axlebox, and where models are designed with cylinders having valves on top or below, it is then possible to set in the frames, and by this means to allow a large amount of lateral play to the leading wheel. A

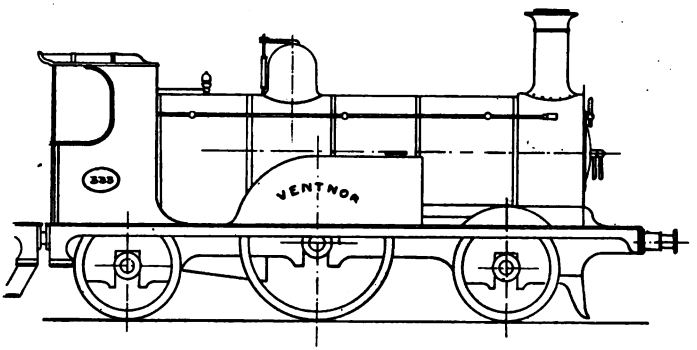


Fig. 16.—London, Brighton, and South Coast Railway Single Express Locomotive.

locomotive thus arranged should be quite as free on a sharp curve as most four-coupled bogie engines, and even if a radial axlebox is not employed, a plain axlebox with side play only being substituted, the wheel-base should not prove to be very rigid.

Figs. 14 and 15 respectively illustrate engines of this type.

Here also a deep firebox is restricted by the length of the coupling rods, and except where small driving wheels are used as in mixed traffic engines (fig. 24), an unlimited length of firebox of the depth required for coal firing is impossible.

The next type of locomotive which may be considered is the once popular class known as the 'single' engine. This type may be divided into those having only six wheels and those with a leading bogie.

The engine depicted in fig. 16 is a six-wheeled single engine with inside cylinders and frames, designed by Mr. Stroudley for the L.B. & S.C. Railway. The chief advantage of this type as regards model work is its simplicity, and, as in all single engines, the firebox is more or less unlimited in length, the small diameter of the trailing carrying wheel offering no obstacle to this procedure —an important consideration where the model is intended to burn solid fuel. Inside cylinders of over-all dimensions not too large in width (similar to the design on page 115) being employed, the leading wheel may run in a radial axlebox or in a pony truck, and by this means, together with some side play in the trailing wheel, curves, if not as sharp as possible with other types of engines, of the minimum radii advisable for high speeds, may be traversed by this type of engine with ease. A large amount of the weight can be placed on the driving wheels, making the model quite as powerful as some types of coupled engines, with, of course, much less friction of moving parts. Against the above advantages, however, the reduction in flue-heating surface, water and steam spaces, due to the limitation in the diameter of the boiler barrel by the large driving wheel, has to be considered.

By supporting the leading end upon a bogie truck the class of single-wheeled engine recently brought out on the G.N.R. is obtained (fig. 17). This engine has the good points of a single engine, but, like all leading bogie engines, means must be taken to provide the maximum swing of bogie by using bogie wheels reduced in scale, narrow cylinders, and cutting away or setting in the main framing.

Similar precautions are necessary with the outside cylinder bogie single shown in fig. 18; indeed, the truck in this locomotive, if built exactly to scale, has even less chance to swing than in an

inside-cylinder design, because of the cross-head passing so very close to the tyre of the rear bogie wheel.

A longer firebox is possible with outside cylinder engines of any design, and, in spite of the limitation of the diameter of the barrel in a single-wheeled locomotive, a very powerful free-steam-

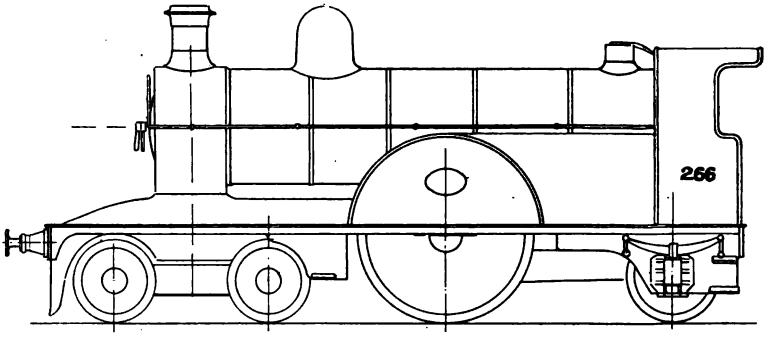


Fig. 17.—Great Northern Railway Inside-Cylinder Bogie Single Engine.

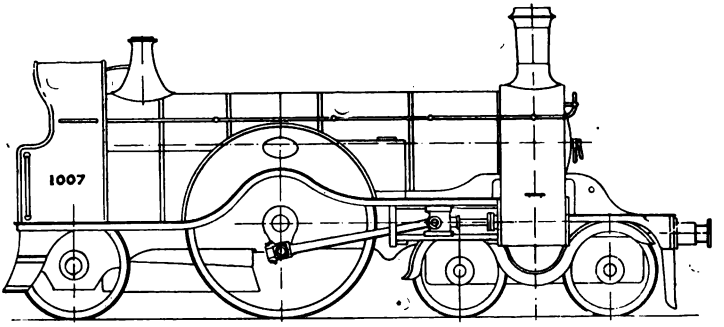


Fig. 18.—Great Northern Railway Outside-Cylinder Bogie Single Engine.

ing engine should be obtained by modelling locomotives of this type. However, the low piston speed consequent on the use of large driving wheels renders a high steam pressure, cylinders of not too large dimensions, and superheating of steam, advisable, otherwise cylinder condensation will be excessive.

Later developments in locomotive engineering have produced two new classes, the six-coupled bogie express and the 'Atlantic' types. The first is depicted in figs. 19 and 20, and the second in figs. 21 and 22.

In the outside-cylinder design, because of the reduction in the distance between the rear bogie wheel and first coupled wheel, the connecting rods are attached to the middle axle of the three,

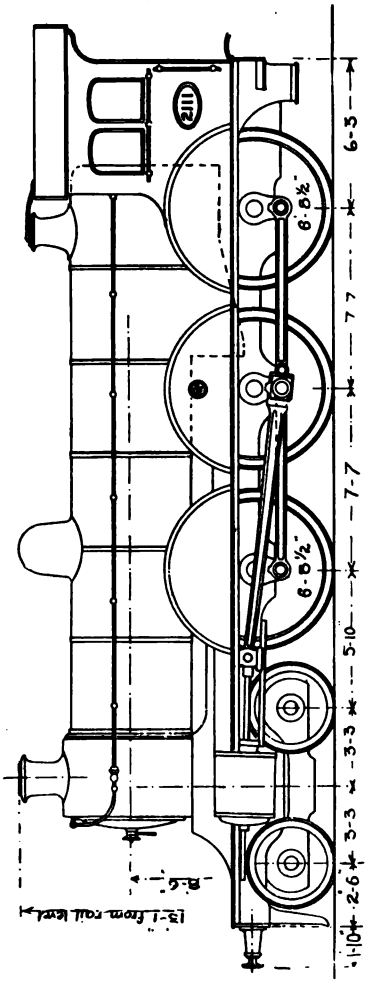


Fig. 19.—Six-coupled Express Locomotive, North-Eastern Railway.

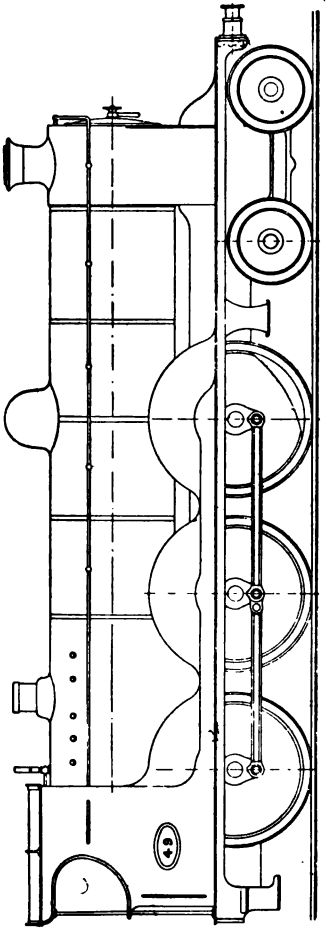


Fig. 20.—Caledonian Railway Six-coupled Express Locomotive.

whereas the Caledonian engine is the outcome of simply lengthening the ordinary four-coupled bogie express locomotive already described (see figs. 10 to 12).

With regard to the merits and demerits of the six-coupled

express type in model work, if a powerful engine is required for hauling the owner, it would seem better to adopt a larger scale and gauge and employ a simpler design of locomotive, such as a small tank engine, but there are no doubt many readers who will choose to model six-coupled locomotives for other reasons, viz., a personal fancy for the type or through having a railway of small gauge already in use, with rolling stock of a given size.

For coal or charcoal-fired models the type presents no advantages, as although a long firebox is possible by extending it over the axles of the coupled wheels, the necessary depth is not obtainable.

In the outside cylinder type (with centre wheels as drivers) the firebox cannot be any larger than may be arranged in an ordinary outside-cylinder four-coupled locomotive as shown in fig. 11. In engines of small size using a methylated spirit-lamp or any system of oil burning where two or more burners can be employed and a shallow firebox alone is necessary, the inside-cylinder (Caledonian) type is certainly advantageous, especially more in the matter of length of firebox than anything else, as the sketch on page 243 will demonstrate.

The 'Atlantic' type and the English modification embodied in the L. & Y.R. ten-wheeler may be considered as a development of the bogie single-wheeled locomotive, the pair of coupled wheels between the bogie and the trailing carrying wheel taking the place of the single pair of drivers. The latter type, both in real and model practice, combines all the advantages of a single and coupled express engine, giving a long deep firebox, and by reason of the smaller driving wheels usually employed, a much larger diameter of boiler is possible. The L. & Y.R. design makes a longer boiler barrel necessary (as the front coupled wheels are the drivers), which, together with the lengthening of wheel-base, is not an unmixed benefit; curves of larger radii will be required, and the extra heating surface in the tubes will as a rule be of little practical value.

Before passing on to goods locomotives there is one type of engine, although not in universal use for passenger work, worthy of consideration by model engine-makers. The type is known as the 'front-coupled' express engine, and was first brought into prominence some twenty years ago by Mr. Stroudley, the engineer

to the L.B. & S.C. Railway, on the production of the very powerful 'Gladstone' class depicted in fig. 23.

By taking this locomotive as the prototype, a short model of

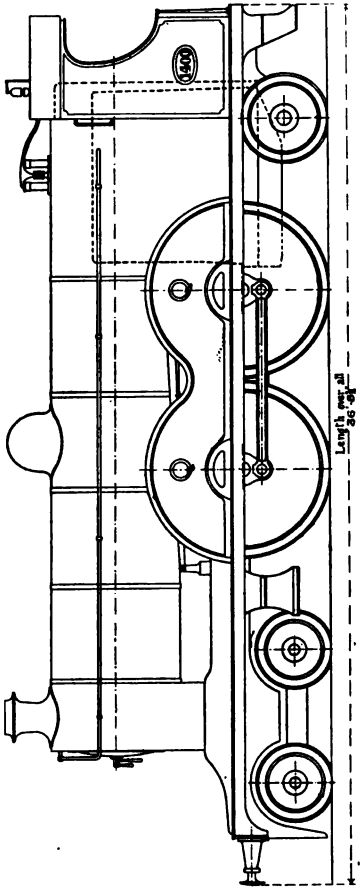


Fig. 21.—Lancashire and Yorkshire Railway Ten-wheeled Express Locomotive.

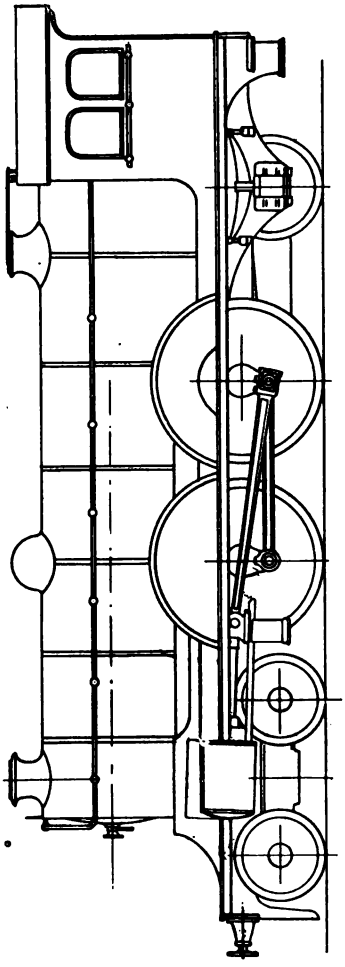


Fig. 22.—North-Eastern Railway 'Atlantic' Express Locomotive.

simple character can be designed, and as a large proportion of the weight of the engine may be placed on the coupled wheels and a long firebox of any depth is easily arranged, the model may be made quite as powerful as one built on the lines of the more pretentious types previously referred to. The

engine has a rather small total wheel-base, and with some side play in the trailing axleboxes, curves of moderate radii should be negotiated.

Locomotives of this type with smaller driving wheels are used for both goods and passenger services, and for this reason are often called 'mixed traffic engines' (fig. 24).

The arrangement of the wheels of 'mixed traffic' engines is in some cases reversed, the type being simply a modification of the six-wheel four-coupled type (see figs. 14 and 15). This is shown in the G.E.R. 420 class (see fig. 25). Larger models which require

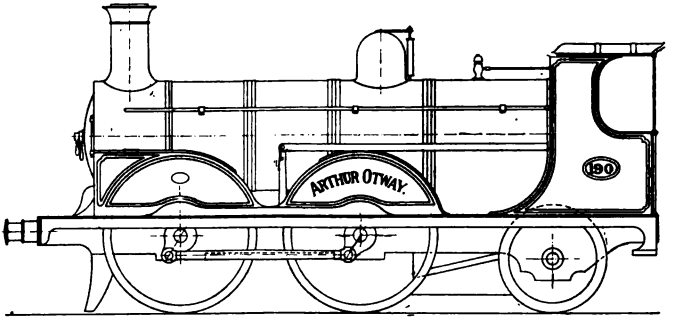


Fig. 23.—Front-coupled Express Locomotive, London, Brighton and South Coast Railway.

solid fuel—adopting this class as the prototype—can be provided with deep fireboxes without regard to the distance between the coupled wheels.

By far the greater number of tender goods engine used within the British Isles are of the very symmetrical design shown in fig. 26. Six-coupled wheels of the moderate diameter of 5 ft. are usually employed, and in general outline and proportions these engines are much the same as the two last-mentioned types, the leading wheel of the four-coupled trailing and the trailing wheel of the front-coupled engines being replaced by a coupled wheel. The whole weight of the engine is, of course, available for adhesion, but curves upon which models built in accordance with this design are to run must be of about twice the radius necessary in other examples of locomotive practice. Eight-coupled engines are now largely employed on English railways for hauling heavy

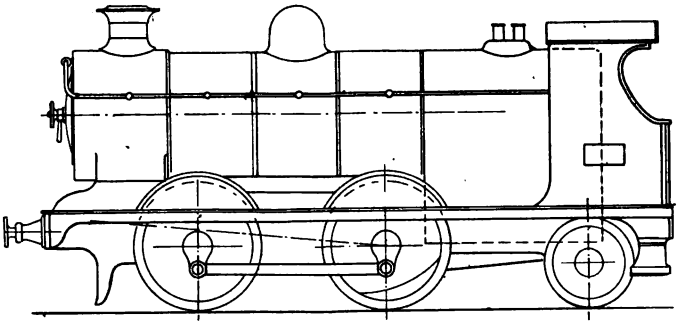


Fig. 24.—A Design for a Mixed Traffic Engine.

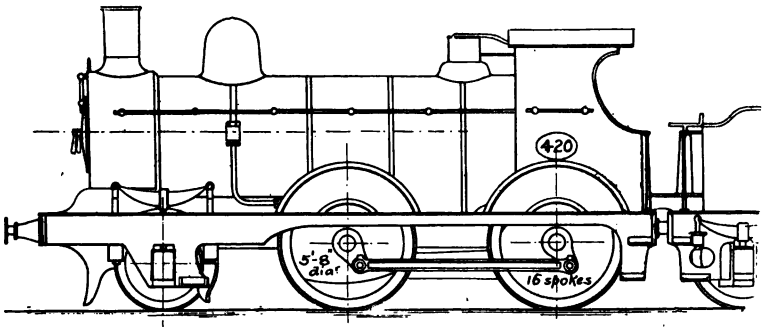


Fig. 25.—Great Eastern Railway Mixed Traffic Engine.

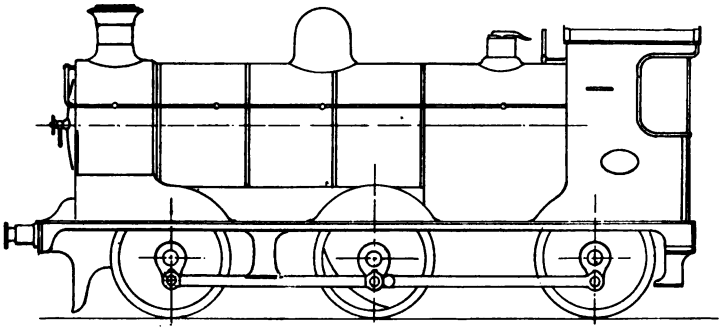


Fig. 26.—Goods Engine, Caledonian Railway.

mineral trains, and two well-known types are illustrated by figs. 26 and 27.

With regard to the possibilities of modelling such locomotives the remarks made in considering the 'standard' six-coupled goods engines may be applied in the case of eight-coupled engines. The type provides a long boiler barrel and firebox, but it is

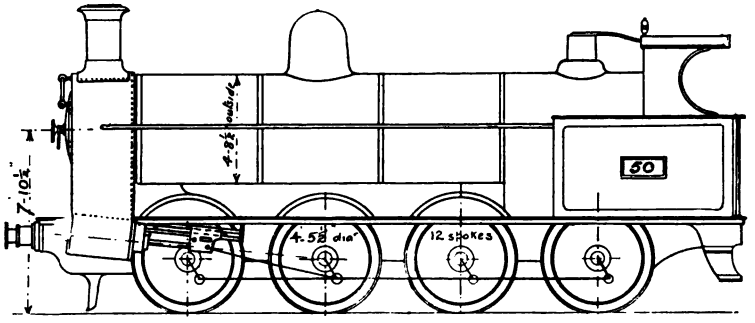


Fig. 26A.—Compound Goods Locomotive, London and North-Western Railway.

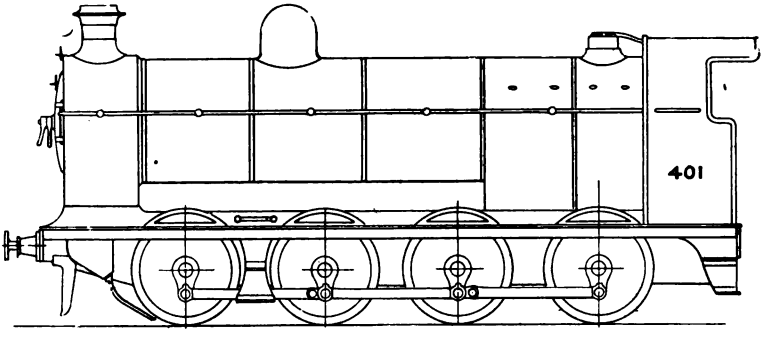


Fig. 27.—Great Northern Railway Eight-coupled Goods Locomotive.

doubtful whether any benefits will accrue from the adoption of an eight or ten-coupled design. Such a large amount of adhesive weight is seldom required in model work; and again, the proportion of maximum tractive force and adhesive weight may be varied from the customary 1 to 5 in dealing with the average model.

Tank locomotives are a very numerous class in this country

and on the Continent (more so than in America), and, as the name implies, consist of a locomotive with the water tank and fuel bunker placed on the one frame instead of on a separate vehicle.

The wheel-base, boiler, and cylinder arrangements are of course much the same as in tender engines; indeed large tank engines, except that an extra pair of wheels is added 'astern' to increase the bunker capacity, are often built to the same drawings as mixed traffic engines.

A simple type of passenger tank is shown in fig. 28. This engine—not regarding the tanks—is a copy, on a much reduced scale, of the now old-fashioned six-wheeled four-coupled tender

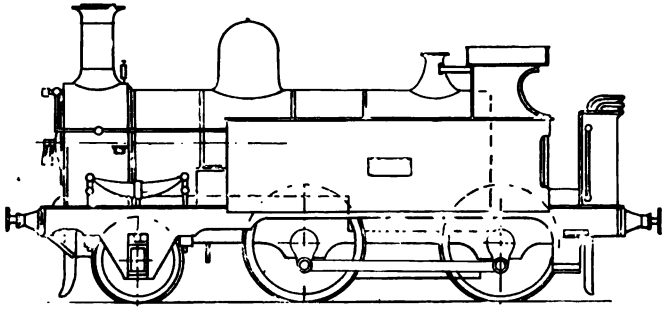


Fig. 28.—Great Western Railway Small Tank Engine.

engine. Although the wheels are small in diameter, without resorting to excessive overhang at the back or the provision of little bunker space, the firebox cannot be of very great length. The type has, however, excellent points, and is one admirably suited for a beginner to model. The leading wheels may be mounted in a pony truck, and sharp curves negotiated. Where the builder desires a powerful engine with as little trouble as possible—for instance, a model locomotive to pull one or two persons, with coal or charcoal fuel, to, say, 1¼-in. scale—this design should fulfil the purpose admirably. The cab is open, and the regulator, etc., can be easily manipulated from a separate truck upon which the driver rides. The same remarks apply to the design shown in fig. 29, as radial trucks may be used in either type, perhaps, for some scales, more easily in the first-mentioned

class of locomotive. The capacity of bunker of a tank locomotive may be increased by adding another wheel, which should as a rule be fitted with a radial axlebox, at the rear end of the engine (fig. 28) as shown in fig. 30.

Figs. 31, 32 and 33 comprise designs which are simply modifica-

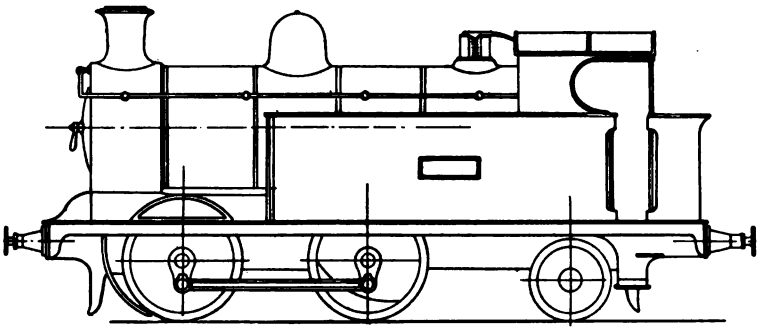


Fig. 29.—A Design for a Six-wheeled Tank Engine.

tions of tender four-coupled bogie and six-coupled goods engines. One point is worthy of mention with respect to the ten-wheeled bogie tanks, and that is, whereas the four-coupled express loco-

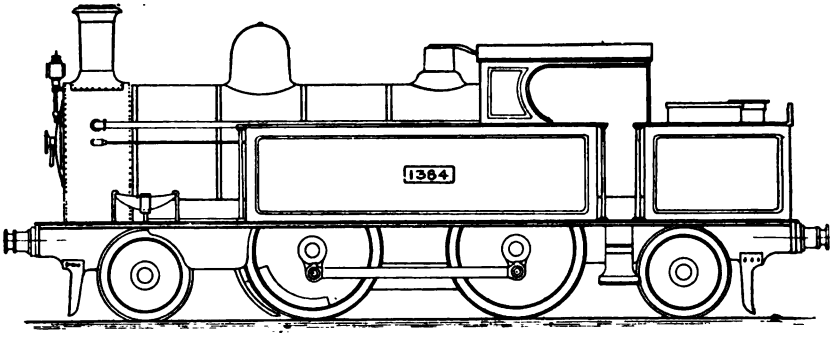


Fig. 30.—London and North-Western Railway 'Double Ender.'

motive generally lacks adhesive weight unless the rear part is heavily loaded by cast footplates, etc., when the type is modified by placing the extra pair of wheels behind the coupled wheels the centre of gravity of the engine generally falls at a point between the coupled wheels, and it will be found possible to arrange that

the major part of the weight of the engine shall rest upon the coupled wheels. Again, the additional weight of the engine, due to the tanks, etc., will render this type very much more powerful than many express locomotives with tenders, and at the same time

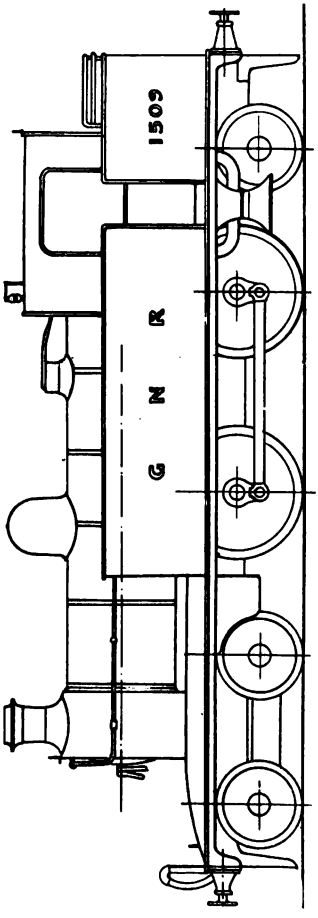


Fig. 31.—Great Northern Railway Ten-wheeled Tank Locomotive.

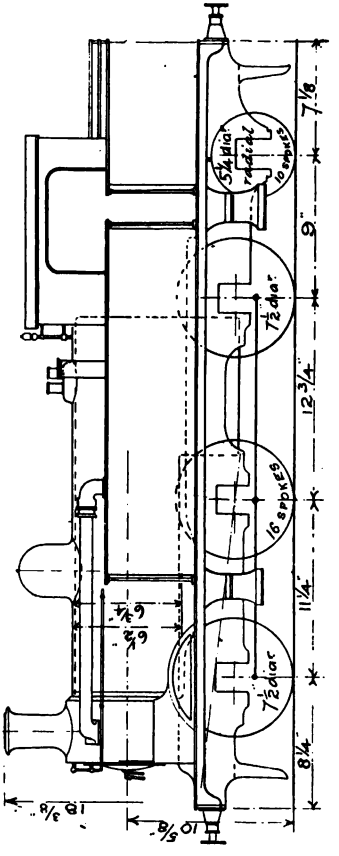


Fig. 32.—Goods Tank Locomotive, Metropolitan Railway.

the model will be very much smaller and more compact. The writer has found that by judicious selection of springs the weight can be taken off the carrying wheels almost entirely; of course this is not advisable or necessary, but shows the inherent advantages of the type. Certainly, the tank engine has the merit of

being a self-contained engine and with a removable roof in the smaller sizes, the locomotive, where such is not intended to be ridden upon, will be quite as easy to manipulate as any express engine.

For shunting purposes and short journeys, goods and passenger

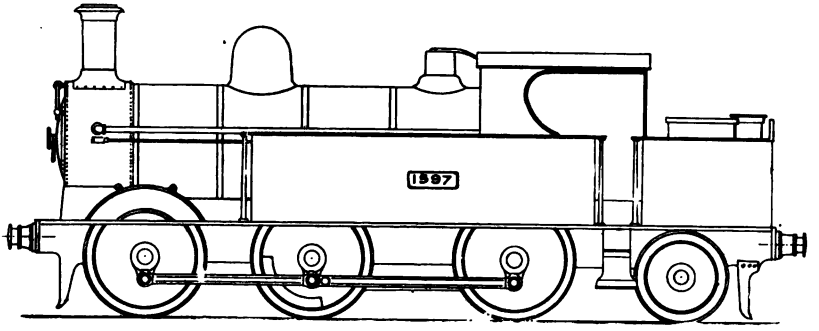


Fig. 33.—London and North-Western Railway Goods Tank Engine.

tank engines with four or six-coupled wheels only are often used, as shown in figs. 34 and 35. In both types firebox length and bunker space are limited, although this may in a large

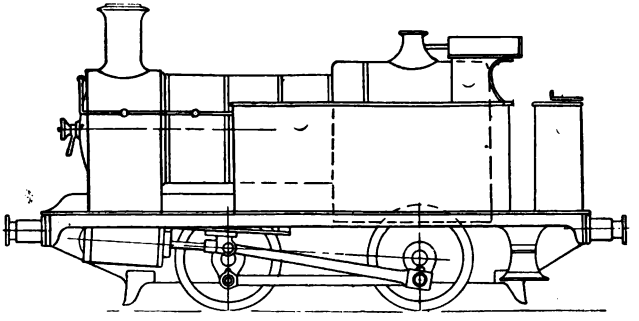


Fig. 34.—A Design for a Four-wheel Shunting Tank Engine.

degree be overcome in the four-wheeled engine by modifications shown in the simple design for a model on page 253. The four-wheeled tank locomotive is much the best type to adopt where very sharp curves are a neccssity.

There are other types of tank engines, notably the G.E.R.

'Decapod' and the G.N.R. eight-coupled No. 116, but these do not present any advantages to the model-maker. Some tank engines have the water tank on top of the boiler instead of at the side, and are then known as 'saddle-tank engines.'

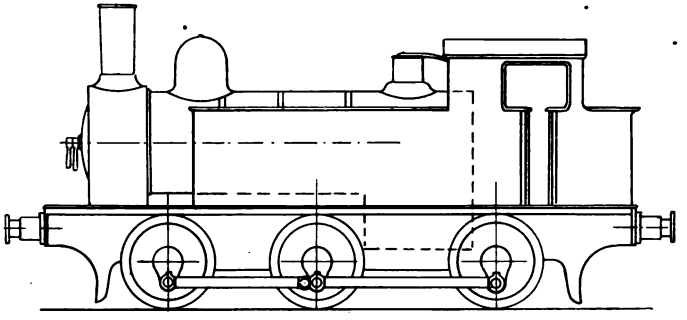


Fig. 35.—Great Eastern Railway Shunting Tank Engine.

Concluding this chapter on locomotive types, special reference must be made to one species, largely employed in this country, which embodies many features of more than passing interest to

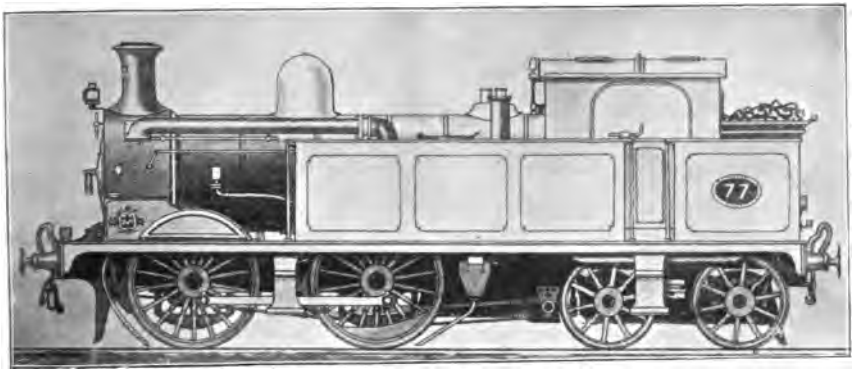


Fig. 36.—Metropolitan Railway Trailing Bogie Passenger Tank Locomotive.

the model-maker. The type gives a short coupled wheel-base. At the cylinders the maximum width of frames is available; the fire-box, in length and width, and the bunker spaces, may be of the largest dimensions, and also the weight on the coupled wheels

should be considerably more than half the total weight of the engine. Such an engine will be found to work out much shorter in over-all dimensions than a ten-wheeled tank locomotive, and will be less costly. The rigid wheel-base in this type of locomotive, an example of which is shown in fig. 36, is never very great.

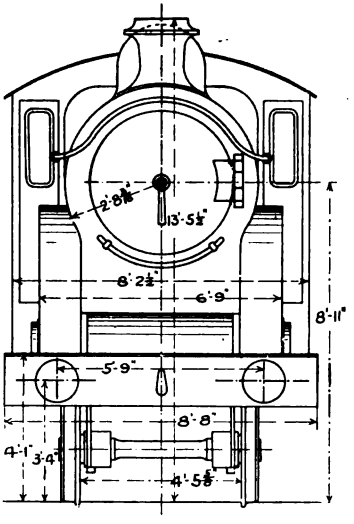


Fig. 37.—Lancashire and Yorkshire Railway Ten-wheeler, Front View.

CHAPTER III.

The Principles of Model Locomotive Design.

It is presumed at the outset that the reader is fully acquainted with the action of the piston in the cylinder of a locomotive engine, and with the manner in which the 'work done' by these parts is communicated to the wheels.[1]

The next step in the study of the mechanism of the locomotive is the thorough comprehension of the movements of the slide valve, the effects of lap and lead, and the use and design of valve gear, all of which points will be discussed later on.

To arrive at the size of the locomotive required for a given duty it is necessary to know, not only the tractive force of the engine, but the resistance to the movement of the train which it is necessary for the locomotive to overcome.

Although it has not been possible for the writer to plot an accurate curve or give a reliable formula for model train resistance, owing to the very varying conditions and sizes, and the elaborate nature of the measuring appliances necessary, readers will find that if they calculate on a resistance of 1 lb. in 20 lb. for small models, and 1 lb. in 25 lb. for large engines, they will not be very far wrong, including the weight of the engine in the total load to be moved.

It is evident that the resistance of the train should be more than balanced by the tractive force of the locomotive, and taking

[1] In case of any difficulty, reference may be made to Mr. Charles S. Lake's *The Locomotive Simply Explained*, a sixpenny handbook which may be obtained from the publishers of this volume.

a practical case for a $\frac{3}{4}$-in. scale railway as an example, we may formulate as follows:—

The load to be pulled	is to	tractive force
as 20	is to	1.

Therefore if engine weighs 40 lb., and a train of ten coaches of 10 lb. each is to be drawn, the sum is:—

40 lb. + 100 lb.	is to	T.F.
as 20	is to	1.

Therefore as T.F. is $\frac{1}{20}$ of load to be pulled,
The tractive force required = 10 lb.

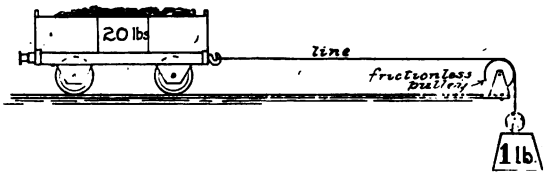


Fig. 38.—A Sketch showing how the Resistance of a Model Train may be Measured.

The formula universally used for finding the theoretical tractive force of a locomotive is

$$\text{Tractive force} = \frac{D^2 \times L \times P}{DW}.$$

Where
D = Cylinder bore in inches.
DW = Diameter of driving wheel in inches.
L = Length of stroke in inches.
P = Steam pressure in lbs. per sq. in.

This may look formidable, but simplified, it is:—

Tractive force = Dia. of cylinder × dia. of cylinder × length of stroke × steam pressure ÷ the diameter of driving wheel, all dimensions being taken in inches (or like terms).

In the case in point the tractive force equals 10 lb.; an engine with a cylinder $\frac{7}{8} \times 1\frac{1}{2}$, $3\frac{1}{2}$-in. driving wheels, and an average steam pressure of, say, 30 lb. in the cylinder should suffice, as the following will prove:

$$\text{T.F.} = \frac{\frac{7}{8} \times \frac{7}{8} \times 1\frac{1}{2} \times 30}{3\frac{1}{2}} = \text{nearly 10 lbs.}$$

It will be seen upon a few examples being worked out that an

increase in the diameter of the driving wheel will diminish, and any increase in cylinder diameter, length of stroke or steam pressure, will augment the tractive force.

If only one double-acting cylinder is employed, the result of the working will have to be halved, the same procedure applying if two single-acting cylinders are used.

The tractive force of compound locomotives is best calculated by arriving at the mean pressures in the cylinders with imaginary indicator diagrams.

By the use of the $\frac{D^2 \times L \times P}{DW}$ formula, not only can the values of various cylinders and driving wheel dimensions be compared, but the proper ratio of the tractive force to weight on the driving wheel may be determined. In real locomotive practice the maximum tractive force exerted is generally arranged to bear a proportion of 1 to 4 or 5 of the weight available for adhesion, that is, weight on driving, and coupled wheels, if any.

In small work the author has found that slipping will not occur on the average model rail if the tractive force does not exceed one-third of the adhesive weight, and as a guide, the designer is referred to Chapter I., in which the average weights of model locomotives are given, the probable adhesive weights being estimated by references to the loads on the several wheels in the prototype.

The total weights of engine and tenders are given, and a deduction of about half to one-third must be made from the figures given, to get an idea of the weight of the locomotive itself.

Theoretical considerations such as the foregoing may be thought unnecessary, but as so many disappointments have occurred through absolute reliance upon dimensions which have been as nearly as possible simply scaled from working drawings of prototypes, it appears advisable to urge model engineers to go to the root of the matter and to design their models with a strict eye to the mechanical laws involved, which *remain the same* whatever may be the size of the machine in which they are concerned.

It is not the best course to fix the size of the cylinders without consideration of all the points, otherwise the result may be that the cylinders are so small that a very high pressure is required (although this is a lesser evil, and is not a common occurrence),

or so large that they unduly drain the boiler and that the latter will only upkeep a comparatively low pressure of steam. In the former case a very strong boiler will be necessary; in the latter absolute failure may result by reason of the excessive cylinder condensation which follows the employment of a low pressure, and therefore a low temperature, steam.

A good rule is to make the *dimension* of the scale of the model the *bore of the cylinder*, the stroke being a scale reduction of that of the prototype.[1] In ½-in. scale, engines will, under this rule, work out at ½ × 1 in., and in 2-inch scale at 2 × 4.

Modifications should only be made in special cases, and in the smaller locomotives the sizes should not be exceeded. A ¾-in. scale engine having a boiler of sufficient power may be provided with cylinders up to ⅞ in., or larger if the adhesive weight will allow. Generally, in the event of superheating not being possible, such liberties with the rule are inadvisable. Locomotives with big driving wheels may have greater cylinder capacity, the increase being mainly obtained by the use of the maximum piston stroke.

When the subject of steam pressure is being considered it must be noted that although the steam pressure at which a model is to work is often arbitrarily predetermined, the steam pressure *maintained* will depend upon many things—cylinder sizes, speed, evaporative power of boiler, amount of cylinder condensation, firing arrangements, fuel, and the completeness of the combustion.

Reference to scale pressures is the wrong method. For instance, the 'scale pressure' of a ½-in. scale model locomotive would be about $\frac{1}{24}$ of 150 = about 6 lb.—a quite unsuitable pressure for a practical working steam locomotive.

By reason of the exposed positions of the cylinders of a small model locomotive the minimum pressure would seem to be about 20 to 25 lb. The table on the following page gives suitable pressures for models of various scales.

The chief value of the higher pressures is the fact that the consequent increase in the temperature renders the engine less wasteful, decreasing the loss by initial condensation, and for this very reason model engines which have their cylinders reduced

[1] The piston strokes of modern locomotives range from 24 in. to 26 in.

and the *nominal* tractive force correspondingly decreased are in practice really rendered more powerful because of the higher steam pressure maintained by the boiler and the reduction in the losses through initial condensation and priming, both of which contribute to the amount of work obtained from the engine per unit quantity of steam consumed.

Too high a steam pressure, besides requiring the use of a very strong boiler, presents no equal advantages, as it will be found after a certain point, that the losses by leakage and radiation (owing to the greater difference in the external and internal temperatures) nullify further efficiency.

TABLE OF SUITABLE STEAM PRESSURE.

Inch.	lbs.	Temperature of Steam—Fahr.
$\frac{3}{8}$	= 20 to 25	259° to 267°
$\frac{1}{2}$	= 25 to 35	267° to 280°
$\frac{5}{8}$	= 30 to 40	274° to 287°
$\frac{3}{4}$	= 30 to 50	274° to 298°
1	= 40 to 70	287° to 316°
$1\frac{1}{2}$	= 60 to 80	307° to 324°
2	= 100	338°

It needs no special mention that a model steam engine is very wasteful as a heat engine; indeed the smaller the engine becomes the more inefficient it is. This is in a large measure due to the following circumstances:—

Geometrically the cubical capacity of a solid does not vary in direct proportion to its external surface, and from this it will be seen that the cooling surfaces of a steam cylinder will be greater in proportion to the capacity contained therein in a model than in a large engine.

To emphasise this fact, and to show the cause of the excessive cylinder condensation ever present in miniature steam locomotives, the writer some time ago prepared the accompanying diagram (fig. 39). The diagram shows that whereas in the large engine the proportion of heat in a cylinder full of steam is to the radiating surfaces of the cylinder about 1 to 1·1, in a small engine the proportions are entirely different, one unit of heat having about 85 square

inches of cooling surface to dissipate it. The point is to a large degree proved in practice, by the fact that the cylinders of large petrol engines are not air-cooled. Above a certain size it is impossible to provide sufficient cooling surface, the heat in the cylinders growing in much greater proportion to the increase of the radiating surface as the power and size of the engine is augmented. Therefore the waste of heat (which is required in petrol engines) does not increase directly with the power of the engine with given cooling arrangements.

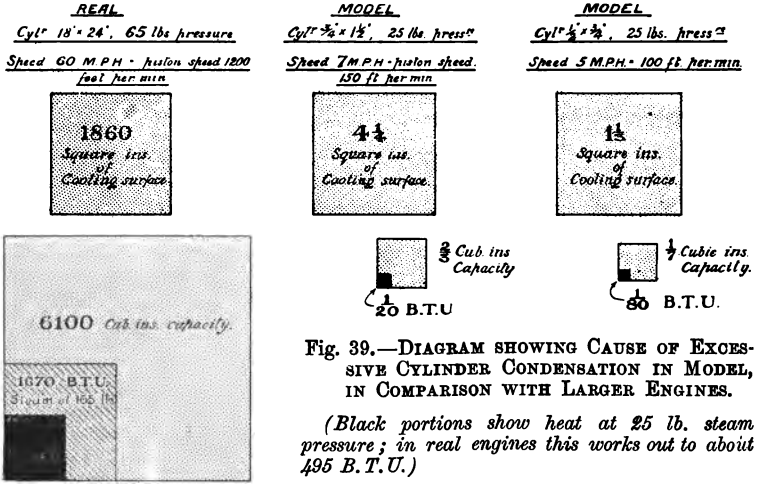

REAL
Cyl' 18" x 24", 65 lbs pressure
Speed 60 M.P.H - piston speed 1200 feet per min
1860 Square ins. of Cooling surface
6100 Cub ins. capacity
1670 B.T.U.
MODEL
Cyl' 3/4" x 1 1/2", 25 lbs. press"
Speed 7 M.P.H - piston speed 150 ft per min
4 1/2 Square ins. of Cooling surface
3/5 Cub ins Capacity
1/20 B.T.U
MODEL
Cyl' 1/4" x 3/4", 25 lbs. press"
Speed 5 M.P.H - 100 ft per min
1 1/2 Square ins. of Cooling surface
1/7 Cubic ins. Capacity.
1/80 B.T.U.

Fig. 39.—Diagram showing Cause of Excessive Cylinder Condensation in Model, in Comparison with Larger Engines.

(Black portions show heat at 25 lb. steam pressure; in real engines this works out to about 495 B.T.U.)

In the above diagram (fig. 39) lower rectangles represent the amount of steam in cubic inches, and the black portions the units of heat, whilst the upper shaded squares indicate the number of square inches of cooling surface, all the figures being plotted to scale and resolved to a common size.

Cylinder condensation to a greater or lesser extent being inevitable, the question then is: What can be done to increase the efficiency of the model by the mitigation of this fault? In the following paragraphs the various methods which can be adopted to prevent or reduce cylinder condensation may be cited:—

(1) Increasing the pressure of the steam above the scale pressure. (This will of course necessitate the reduction

of the cylinder bore, or else the boiler will prove insufficient; also the slipping of wheels will be probable.)

(2) Superheating the steam. Superheating is giving the steam a higher temperature than that of the corresponding pressure; see table on page 45. (A lower pressure can be used if the superheating is carried to a considerable extent.)

(3) Lagging all parts which contain steam with non-conducting material.

(4) Increasing the piston speed. This can be attained by using a small driving wheel and employing a cylinder with a moderately long stroke. The increased speed gives less time for the condensation to take place.

Of course the above remedies are more effectual if used in conjunction with each other. It is very difficult to lay down hard and fast rules, but in any case a judicious choice and careful proportioning of the 'preventatives' will give the best results.

To revert to the subject of suitable steam pressures: a $\frac{1}{2}$-in. or $\frac{5}{8}$-in. scale boiler is not usually provided with lagging, and therefore with models of this size a very high pressure cannot be employed so economically, because of the greater differences in the temperature of the steam in the boiler and the atmosphere, as already mentioned. A noticeable reduction in the quantity of water evaporated by the boiler will be experienced out of doors even on a day which would not be called a cold one. The loss by radiation would be proportionate to the difference in temperature of the boiler and that of the air, and therefore if a high pressure steam with its corresponding high temperature be used, it will be seen that the loss due to the bareness of the boiler barrel will be greater.

The writer has not up to the present been able to record any case (excepting in $1\frac{1}{2}$ and 2-in. scale model locomotives) where the expansion of steam in the cylinder by means of increasing the lap of the slide valve, linking-up, or compounding in small steam engines of any type, has resulted in any appreciable saving in steam, but this may be the fault of those responsible for the experiments not constructing the apparatus in a proper mechanical manner or thoroughly understanding the nature of the 'fluid'

they were dealing with. It must be urged, however, that the compound or other model locomotive provided with means of expanding the steam will not be a success unless it is worked out in a scientific manner.

It would appear that although a certain percentage of gain can be obtained by expanding the steam on more than one cylinder, this increased output per unit of steam consumed by the engine is more than counterbalanced by the power required by the extra parts of the machine. If real saving is to be effected, it seems that the most simple way to do it is by the use of a simple engine fitted with some semi-automatic device which will link up the valve gear and can be operated after the engine has started. With reference to this there however appears to be a limit to the expansion if ordinary saturated steam is used, and it has been found that the initial condensation is increased to an alarming extent when the cut-off is earlier than five-eighths to three-quarters of the stroke. To prevent this rendering any saving in steam null and void, some method of preventing liquefaction in the cylinder must be adopted.

The only effectual cure is in the provision of a superheated supply—*i.e.* the use of steam of higher temperature than that of saturation. The gain in a simple engine arranged with a cut-off at half stroke,[1] or in a well-designed compound model, should theoretically amount to about 20 to 25 per cent.

In the latter instance the extra gear (where three or four cylinders are employed) would, the writer thinks, reduce this saving to nothing, and except for many other advantages of compounding (which, by the way, are not marked in model locomotive practice) no benefit will accrue.

In the former case the question is, Is it worth the trouble in tiny locomotives?[2] and it is left an open one for the ingenious reader to solve. However, one or two general hints may be given on this intensely interesting point.

A two-cylinder compound would appear to offer the best chance

[1] The cut-off must be quite three-quarter stroke in full gear, else the engine will not always start. The earlier cut-off should be obtained by linking-up only, not by the provision of a considerable amount of lap in the first case.

[2] On engines upon which the owner may ride, linking-up is a *sine qua non*, and as it is so easy to do this, compounding is not worth the extra trouble.

of success, as little in excess of the ordinary machinery is necessary. There are only two beats (*i.e.* puffs) instead of four per revolution, and this may interfere with the induced draught.

Four-cylinder (Webb system) is a comparatively simple arrangement, as one set of valve gear may be made to serve two cylinders (see Chapter VII., p. 131). The three-cylinder (Smith's) system is a good one, but is complicated, three sets of motion being required.

The steam pressures should for compound be not less than 70 to 100 lb., and it must be pointed out that a stronger boiler than is necessary for a simple engine will be required. Superheating is of course advisable. The high-pressure cylinders should be of a size which will render it possible for the boiler to supply the high pressure continuously, as when the steam pressure falls below, say, 60 lb., the low-pressure cylinders will very likely contribute nothing to the work of the engine. The cylinder should have a capacity ratio of about 1 to $2\frac{1}{4}$ or 1 to $2\frac{1}{2}$, and an early cut-off in either the H.P. or L.P. cylinder should not be attempted.

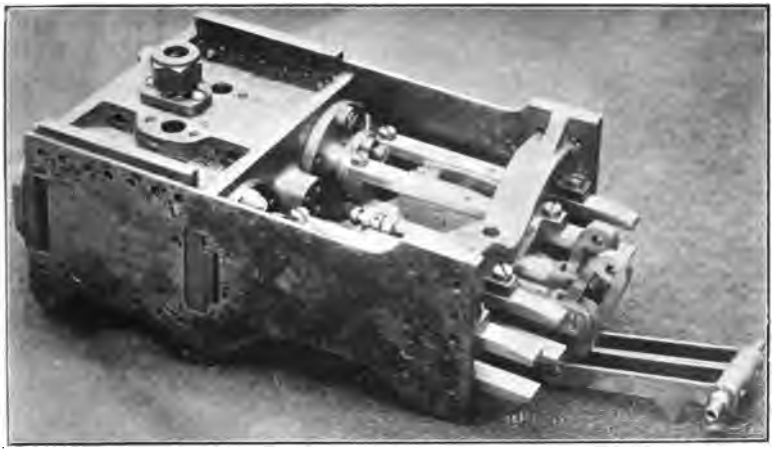


Fig. 40.—Cylinders and Auxiliary Frames for a Model Caledonian Locomotive.

Made by Mr. W. H. Dearden.

CHAPTER IV.

The General Consideration of Boiler Design.

The chief difficulties of model locomotive making usually arise in connection with the provision of a boiler of sufficient power to drive the engine continuously, and therefore in this chapter the writer will deal with the question of boiler design exclusively, giving rules for fixing the amount of heating surface required for various dimensions of cylinders and other conditions.

Although great liberties may be taken with regard to the internal arrangements of a model locomotive boiler where the orthodox type is retained, the same care must be taken in providing proper means to ensure the maximum evaporation of the water, viz., in smokebox arrangements, grate area, perfect combustion of the fuel, and steam tightness, as in the real engine.

Again, the dimensions of the boiler of a railway engine being bounded by certain limits of height, length, and width, the designer of the model will be handicapped in the same way as the locomotive superintendents of this country are, more especially in this decade.

The limits of height and width are called the loading gauge, the dimensions of the English standard[1] being included in the $\frac{1}{8}$-in. scale diagram, fig. 9, Chapter I. In America and on the Continent, whilst the rail gauge for the main lines is the same, the allowed height and width of the vehicles are very much greater, the maximum height in the first-named country being about 15 ft. 6 in. and the over-all width about 10 ft.

It would appear at first sight that the loading gauge does not

[1] English railway companies loading gauges vary slightly; the largest dimensions of all are embodied in the diagram.

affect the boiler materially (except as regards height), but in fact it actually does so. The diameter of the boiler can be considerably increased in size, and the width of the firebox very much augmented, where the distance between rail level and boiler centre is unrestricted. For this reason it is best to consider this matter at the outset by making a cross-section of the proposed model through any point where it is possible for the machinery or frames to foul the boiler or firebox.

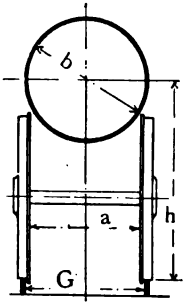


Fig. 41.

At the driving wheels it will be found that the diameter of the barrel (*b*, fig. 41) is limited by the distance between the tyres of the wheels (*a*) and the height of boiler centre from the rails (*h*), and of course the firebox cannot be any wider than the rail gauge will allow unless the foundation ring rests on the main frames (see Plate IX.) or is placed behind the driving wheels as shown in the design described by Plate III., or over the wheels, as can be arranged in a small-wheeled type of locomotive.

The ideal requirements of a model boiler are as follows:—

It should provide a good circulation for the water, complete ventilation of the fire; should be of the proper strength, have ample heating surface for its size, a large range of water, and sufficient capacity for a good reserve of steam. The grate area should not in any case be small, and the smokebox arrangements should be perfect. It should be designed with due regard to the fuel to be employed.

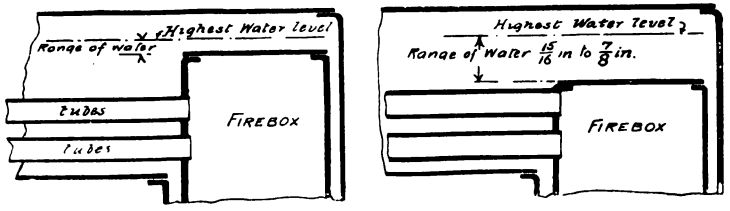
The proportions of a model boiler depend upon one another, and the designer should beware of the common pitfall of providing plenty of heating surface but curtailing the water and steam spaces to a degree bordering upon absurdity. Cases might be cited where the boiler has fairly large surfaces combined with an extremely small firebox; others, whilst having plenty of room for burners or fire, have so little tube area that half the heat evolved is wasted up the funnel.

A very common mistake is depicted in fig. 42—one which the writer is constantly correcting in designs submitted to him. Instead of keeping the crown as nearly as practicable down to the

level of the top of the flue tubes, it is shown, as indicated, some distance higher than it need be; and instead of the range of water in a $\frac{5}{8}$-in. scale locomotive being, say, $\frac{1}{16}$ or $\frac{7}{8}$ in., it is reduced to $\frac{1}{4}$ in., which means that the time during which the locomotive can run without replenishing is about a third of what it might be.

A table is here included by the help of which, without calculation, desirable proportions of heating surface, grate area, steam and water space (measured from crown of firebox to roof of barrel) for given scales and cylinder dimensions may be obtained. The figures may of course vary slightly under different conditions.

A very good rule for settling the heating surface of a model locomotive is to multiply the cubic capacity of both cylinders by 70 in large engines and 120 in small engines, the result equalling



The wrong method. The correct method.

Fig. 42.—FIREBOX DESIGN.

the required heating surface in square inches. This rule, of course, may be used in the opposite way, and the cylinder diameter and stroke determined from the heating surface of a given design of boiler.

If superheating is to be adopted, this rule may be used with some degree of latitude, and a larger cylinder capacity than it provides employed. Small-wheeled engines should not be provided with cylinders so large as to cause the wheels to slip owing to excess of tractive force at starting, neither will it be wise to make the cylinders of such a diameter even if the procedure is warranted by a consideration of the heating surface alone.

Another good guide which works admirably in practice, especially where the cylinders are fixed by the rule given on page 44, is: Heating surface = 300 × scale × scale,* which in the case of an

* Or scale squared.

engine built to a scale of $1\frac{1}{2}$ in. to the foot, works out as follows :—

$$\text{H.S.} = 300 \times 1\tfrac{1}{2} \times 1\tfrac{1}{2}$$
$$\text{H.S.} = 675 \text{ sq. in.}$$

There are, of course, cases where a variation from this rule will not be attended with failure; for instance, a $\frac{5}{8}$-in. scale locomotive with a water-tube boiler (see Plate III.) need only have 90 sq. in. and yet be perfectly successful, whereas the last-mentioned rule would dictate a heating surface of 120 sq. in.

$$\text{H.S.} = 300 \times \frac{5 \times 5}{8 \times 8} = \text{nearly } 120 \text{ sq. in.}$$

This success is due to these small boilers being suited to the kind of firing (methylated spirit wick lamp) usually employed in connection with them.

TABLE OF BOILER PROPORTIONS.

Scale,	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	2 in.
Loco type—							
Boiler diameter, .	$2\frac{3}{4}$	$3\frac{1}{2}$	4	5	$6\frac{1}{4}$	$7\frac{1}{2}$	$10\frac{1}{2}$
Water and steam spaces, . .	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{3}{4}$	$3\frac{1}{4}$	$4\frac{3}{4}$
Tubes, diameters, .	$\frac{5}{16}$–$\frac{1}{2}$	$\frac{3}{8}$–$\frac{1}{2}$	$\frac{7}{16}$–$\frac{5}{8}$	$\frac{1}{2}$–$\frac{3}{4}$	$\frac{5}{8}$–$\frac{3}{4}$	$\frac{1}{8}$–$\frac{3}{4}$	$\frac{3}{4}$–$\frac{7}{8}$
,, numbers, .	8–5	12–7	13–7	16–9	16–11	24–18	30–20
Heating surface, .	60	120	160	325	480	700	1300
Cylinders, . .	$\frac{1}{2} \times 1$	$\frac{5}{8} \times 1\frac{1}{4}$	$\frac{13}{16} \times 1\frac{5}{8}$	$1\frac{1}{4} \times 2$	$1\frac{3}{8} \times 2\frac{1}{2}$	$1\frac{3}{4} \times 3$	$2\frac{1}{4} \times 4$
Water-tube type—							
Cylinders, . .	$\frac{7}{16} \times 1$	$\frac{5}{8} \times 1\frac{1}{4}$	$\frac{3}{4} \times 1\frac{1}{2}$	1×2	$1\frac{1}{4} \times 2\frac{1}{2}$	$1\frac{1}{2} \times 3$	...
Outer shell, . .	$2\frac{3}{4}$	$3\frac{1}{2}$	4	5	$6\frac{1}{2}$	$7\frac{1}{2}$	...
Inner shell, . .	2	$2\frac{1}{2}$	3	$3\frac{3}{4}$	$4\frac{1}{2}$	5	...
Water tubes, diameter, . .	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$	...
Heating surface, .	40	85	110	200	300	450	...

Again, it is easy to provide a large model of, say, 2-in. scale with 25 per cent. or 33 per cent. more heating surface than the rule gives (this should be done); and, at the same time, difficult to obtain sufficient heating surface for a ½-in. scale model, according to result the rule would advise; nevertheless readers can be recommended to keep on the right side of the rules just given. If this is done the builder will know that it is not insufficient heating surface that is the cause of his model failing—supposing that unfortunate circumstance should arise.

Simple boilers for engines more or less of the toy variety may be made by obtaining a piece of light brass tube and fitting it with ends in a strong manner; and except it be that some two or three small 'in-and-out' water tubes are fitted, this type of boiler will require no firebox, flues or smokebox.

The flame of the spirit lamp usually employed with such generators burns in the open air, not depending on draught, and very often will, for ½-in. scale and smaller models, do *very much better* than the same lamp placed in a nominally more powerful boiler having the orthodox firebox, flues and smokebox. This is solely because the flame of a spirit lamp is better 'ventilated,' and combustion is more complete. It burns in the open air, and requires no induced draught. In the necessarily small firebox of a locomotive type boiler of ½ in. or smaller scales the flame is generally 'choked,' and as the heat given out from a methylated spirit lamp is local, the method of 'outside firing' is in tiny engines very successful.

The next step in small engines is to box in the flame of the lamp by providing a flue and a smokebox as shown in fig. 43 (*b*). This is a simple way to get over the obvious objection of the outside-fired model locomotives, but attention must be immediately paid to the question of draught.

This is not, of course, an ideal arrangement, as the heating surface is small and radiation surfaces are large; but where the cylinder capacity is reduced (as in single-cylindered engines), success is not at all a difficult matter—indeed, it can be assured.

Thanks are due to the perseverance and ingenuity of a well-known model maker—Mr. F. Smithies of Watford, to wit—for a very great improvement in this class of boiler. The invention has

received the writer's close attention for some time past, and by scientific arrangement and slight alteration in general construction, the author can, under certain conditions, recommend it for models as large as 1¼ in.-scale.

Mr. Smithies' improvement of the type shown in fig. 43 consists of providing a shell, to all intents a copy, externally, of the loco-

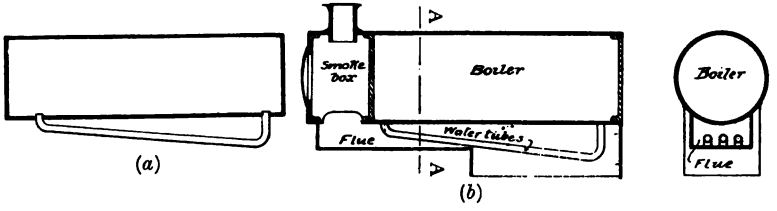


Fig. 43.—Simple Boilers for Model Locomotives.

motive boiler, with the plain cylindrical 'boiler proper' and its water tubes inside, as shown in the cross-sections of the drawing, fig. 44.

It would at first sight appear that the arrangement is a bad one for various reasons, amongst which may be urged that the shell

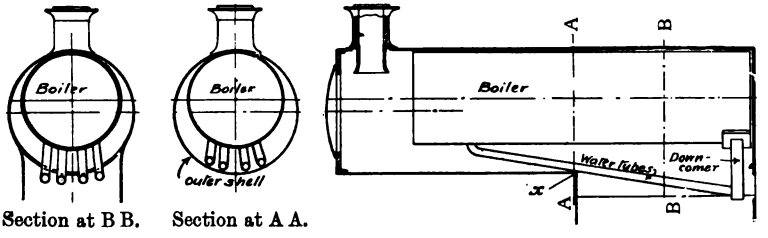


Fig. 44.—Smithies' Water-tube Model Locomotive Boiler.

will absorb a greater part of the heat and the boiler itself get little, and also that a large heating surface is impossible.

These difficulties, however, are neither encountered in practice nor are so formidable as they look. The shell gets fairly warm in small engines, but not so hot as one would imagine, the painting, if done in a dark-colored enamel, standing very well. The water tubes, which are directly over the flame of the lamp, absorb a large proportion of the heat, and the total heating surface, if it is smaller than that obtainable in a fire-tube generator, is of a much more

efficient character, and is in the most suitable place, especially as regards liquid fuel and spirit-burning engines.

The barrel of the boiler proper is *not subject to losses by radiation*, being slung in the heated gases, and as the flues are of large cross-sectional area (compared with a fire-tube engine), and the resistance to heated gases very small, the flame is well ventilated and draught very free under natural conditions, particularly during steam-raising if the smokebox door is left open.

The writer's experience, however, recommends that the following precautions should be taken in designing boilers on this principle :—

The water tubes should not be too small or too large; $\frac{5}{16}$ to $\frac{3}{16}$ in. outside diameter are the best sizes for small locomotives. Water tubes should have a good rise, and should, where one row only is fitted, all but touch the throat plate and barrel joint as illustrated at *x* in fig. 44, and in the cross-section on A.A.

The firebox should be as long as possible. The tubes may be slightly bent with advantage, and should also be hard-soldered in place in small engines, at least at the front joints.

Downcomers of ample cross-sectional area should feed the tubes at the lower ends.

The diameter of the inner barrel should bear a proportion of 3 to 4 or 3 to $4\frac{1}{4}$ to the outer shell.

The lamp in small engines should be as low down as possible.

In large boilers the outer shell will need to be in two thicknesses with non-conducting material between, and the tubes will require a different mode of fixing (see Chapter X.). Solid fuel is not suitable for this type of boiler, owing to fierce local heat at the sides of the box.

These boilers provide a *splendid circulation*, and also have a *very large range* of water level, both of these advantages contributing greatly to their successful career and popularity.

To return to the ordinary locomotive boiler, a few hints are worth mentioning with regard to the design of this type of generator in miniature.

The necessity of ample heating surface has already been touched upon; and especially in engines burning liquid fuels (oil, spirit) in lamps and vaporising burners, the use of water tubes in the firebox is strongly to be recommended. It is in the firebox of a model boiler that a large proportion of the evaporative work is accomplished, and the use of water tubes arranged in one of the many systems given in the designs in later chapters of this book, in each and every case, is emphatically urged.

The large number of small flue tubes used in real locomotives being out of the question for model locomotives, and whilst a single flue will not in the smallest model provide the requisite amount of heating surface, some happy medium must be settled upon, and therefore the table on page 53, which is based on practical data, may help the novice over this difficulty.

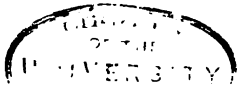
Slightly larger tubes than would otherwise be employed are to be recommended where solid fuel is to be used, and for tiny models it is important that the tubes should be of the lightest material obtainable, as upon this success somewhat depends.

Care should be taken to see that the satisfying of a desire for a large heating surface in a locomotive type generator does not necessitate the crown being high up in the boiler, reducing steam and water spaces, and handicapping the usefulness of the engine to a serious extent.

Too little water is a source of danger, as the crown of the boiler may suffer, and too much of this useful commodity, especially in the cylinders, is a nuisance. The only way to prevent the occurrence of these evils is to keep the crown as low as possible and not increase the heating surface at the expense of the spaces above the crown of the firebox.

The greatest range of water level consistent with the provision of sufficient heating surface is advisable, and in small engines of $\frac{1}{2}$-in., $\frac{5}{8}$-in., and $\frac{3}{4}$-in. scales, the crown should never be higher than the centre line of the barrel. Even in a 2-in. scale model locomotive the crown should not be higher than one inch above the centre line of barrel.

Fireboxes should be hard-soldered (*i.e.* silver-soldered or brazed), and all the flue and water tubes joints in the firebox similarly



treated, or at least prevented from leakage even when the water happens to be allowed to become lower than advisable.

Boilers intended to be fired with solid fuel (coal or charcoal) should have deep grates; this will generally need the provision of a separate firebox shell plate. Otherwise the foundation ring need never be lower than the footplate level, and may be placed on top of the frames, when an increase in the width of firebox will be generally possible, as shown in the cross section of L.N.W.R. design on Plate IX.

It is essential to success that the steam sent to the cylinders should be as dry as possible, and to this end the steam should be collected by perforated collecting pipes or from domes provided with either perforated or other baffles, the area of the holes in the collectors being such as will slightly 'wire draw'[1] the steam, and in this way superheat it also.

One of the most important considerations in model locomotive boiler design and working is the provision of an efficient yet simple method of inducing a draught. *Natural draught is entirely insufficient* to promote the necessary combustion—for one reason, that locomotive chimneys are comparatively very short—and the use of exhaust steam in the chimney by way of a blast pipe, which marked the greatest step in the early progress of the actual locomotive, cannot be disregarded in a model boiler with an enclosed fire and small flues.

The best care is recommended in the matter of smokebox arrangements, and as a general rule, experiment is necessary to determine the most efficient proportions of exhaust nozzle (or blast orifice, to use an alternative term) and chimney.

During the last two years the author has paid particular attention to this branch of model locomotive design, and the following proportions, deduced from practical and successful examples, should enable anyone to settle upon the most suitable proportions for any given scale of model.

As the area of the blast pipe plays an important part in the question, the following rules will be found useful:—

For engines with cylinders of less than $\frac{3}{4}$ in. bore: Area of blast orifice = $\frac{1}{30}$th area of cylinder.

[1] 'Wire-drawing' is the term used for 'throttling' the steam.

For large engines up to 2-in. scale: Area of blast pipe = $\frac{1}{20}$th area of cylinder.

For the medium sizes, $\frac{1}{25}$th is a good proportion.

Practical examples are as follows:—

Scale.	Cylinder.	Orifice.	Proportion.
2-in.	2-in.	$\frac{7}{16}$ diam.	$\frac{1}{21}$
$\frac{3}{4}$ "	$\frac{3}{4}$ "	$\frac{5}{32}$ "	$\frac{1}{23}$
* $\frac{3}{4}$ "	$\frac{11}{16}$ "	$\frac{7}{64}$ "	$\frac{1}{40}$
$\frac{5}{8}$ "	$\frac{11}{16}$ "	$\frac{1}{8}$ "	$\frac{1}{30}$
$\frac{5}{8}$ "	$\frac{1}{2}$ "	$\frac{3}{32}$ bare.	$\frac{1}{30}$

For smokebox and chimney arrangements, the accompanying sketch shows proportions for real locomotives put forward by Von Borries, the great authority on compound locomotives, and also two examples from models built to my designs.

Fig. 45 (*a*) represents the blast pipe and chimney of a 2-in. scale model, (*b*) Von Borries' rule, and (*c*) the arrangement in Mr. Eastabrook's tank locomotive, and the drawings are resolved to a common scale, $\frac{3}{8}$ in. to the foot. It will be noticed that the smaller the model becomes, the lower down it is necessary to place the blast pipe, and that the best proportion between the diameter of the chimney and the height from nozzle to the top of the chimney, in the real engine would appear, by Herr von Borries' diagram, to be as 1 is to 3, see fig. 45 (*b*); in model, success has been obtained by a proportion of about 1 to 5. If the height is limited, then the chimney should have a smaller inside diameter. This is one of the reasons for the use of the liner in example at A, fig. 45.

Whilst these diagrams show that the linear dimensions of successful arrangements are different to those a scale reduction of a given prototype would prescribe, it must be understood that these variations do not prove that the principles are in any way altered by a reduction to scale, but they make very clear that scale reductions, strictly adhered to, are delusive and fraught with danger to the success of the model to which such methods are applied. With regard to the importance of the position of the blast pipe, the writer cannot do better than here recite the conclusions consequent on one of his first experiments in this direction with a $\frac{3}{4}$-in. scale

* This size the writer found too small.

model oil-fired tank locomotive, which was reported in the pages of *The Model Engineer* of June 1st, 1902.

The engine in question is that shown on page 268, and whether it was worked at 500 or 100 revolutions, the production of steam was a directly varying quantity and automatic, as in a real locomotive, by the ejector action of the exhaust steam in the chimney.

The boiler, in spite of its ample heating surface, was not made to

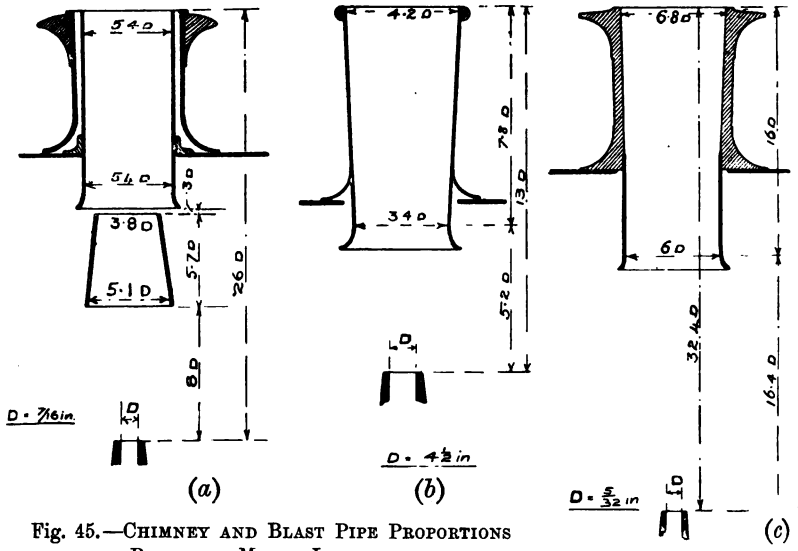


Fig. 45.—CHIMNEY AND BLAST PIPE PROPORTIONS IN REAL AND MODEL LOCOMOTIVES.

steam until some final adjustments had been made, the burner not giving out its fullest heat until the proper height of blast pipe (see fig. 46) was found experimentally. Any fuel requires oxygen to completely burn it, and as a locomotive boiler requires forced draught almost more than any other type to enable it to perform the work required of it, the source of the draught must be attended to. In the real locomotive the proportions and relative positions of the blast pipe and the chimney are important factors, and so with models, more especially those using oil burners and solid fuels. If the working of an oil burner be watched, it will be seen (the steam blower being shut off during the experiment) that it will smoke when the engine is stopped, signifying that solid unconsumed carbon

is being given off; if the engine is run at slow speed the smoking will stop, but the evaporation of water *will not be so great as when the engine is worked at a much higher speed.* The reason of this is that the blast brings only a sufficient amount of air into the firebox to transform the carbon into CO, carbon-monoxide, a colorless gas, giving out fourteen units of heat. If the engine is made to run faster, the more oxygen brought in allows the products of combustion to approach or attain to CO_2, which evolves out in the chemical change twenty-two units of heat. These extra eight units of heat,

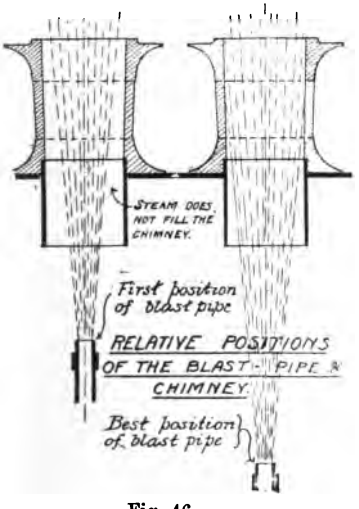

STEAM DOES NOT FILL THE CHIMNEY.
First position of blast pipe
RELATIVE POSITIONS OF THE BLAST-PIPE & CHIMNEY.
Best position of blast pipe

Fig. 46.

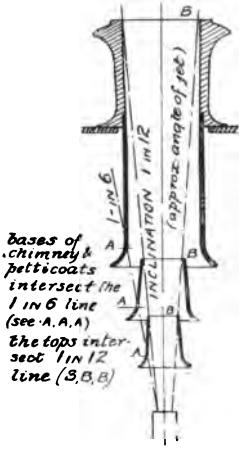

B
1-IN 6
INCLINATION 1 IN 12
(approx angle of jet)
bases of chimney & petticoats intersect the 1 IN 6 line (see A, A, A)
A
B
the tops intersect 1 IN 12 line (B, B, B)

Fig. 47.—METHOD OF PROPORTIONING CHIMNEY, PETTICOAT, AND BLAST PIPES.

of course, produce a correspondingly greater amount of steam and meet the greater demands of the engine.

The original and final arrangements of blast pipe are shown in the sketch. The necessity for the alteration was found by putting a short piece of 1-in. brass tube in the top of chimney, making an extension stack—the effect upon the steaming was most marked.

A very simple graphic method of arriving at chimney and petticoat pipe proportions is shown in fig. 47. Petticoat pipes are to be recommended wherever possible, these additions greatly improving the efficiency of the apparatus.

In a coal or charcoal-burning model the blast of the engine

should keep the fire absolutely bright and clear, lifting the flame at every beat, and maintaining a full head of steam at all speeds. Of course to do this the valves must be properly proportioned and the valve gear accurately set, otherwise, in spite of possibly excellent arrangements in the smokebox, a good draught will not be created. The beats should at, say, 100 revolutions per minute be *absolutely distinct* and occur at *regular intervals.*

The smokebox should be quite airtight, and *it should not be possible for one to see the rails* by looking down the chimney, as in instances which have come under the writer's notice in the past. The blast pipe should also be exactly in the centre of the chimney, the exhaust pipes meeting to form a single jet the direction of which should be truly vertical.

Under good conditions a coal-fired locomotive boiler working at its maximum will evaporate about 2 cub. in. of water per 100 sq. in. of heating surface per minute. Smaller boilers fired by oil will evaporate less—somewhere about 1·5 cub. in. per minute, locomotive type boilers of about $\frac{1}{2}$-in. scale evaporating about $\frac{3}{4}$ of a cub. in. per minute, and Smithies' type about 1 cub. in. per minute per 100 sq. in. of heating surface.

The Strength of Boilers.

The strength of the boiler for a model locomotive should be considered in preparing the design. Of course with given thicknesses of material and diameter a plain cylindrical boiler made from a piece of solid drawn tube will be the strongest, and in this respect the water-tube boiler scores very high, very few joints of a weakening character being necessary. When the shell is made from sheet material rolled into shape with a longitudinal joint, the strength of the boiler depends on the efficiency of this joint. A single-riveted lap joint will work out at about 50 per cent. of the strength of the solid material, and a double-riveted lap joint at 75 per cent. Flat ends should be made $1\frac{1}{4}$ times the thickness of the shell plates, and tube plates thicker still.

To find the bursting pressure of a given cylindrical shell, the following formula may be employed:[1]—

[1] Terms in lbs. and inches.

Copper boilers: 25,000 × plate thickness × 2 ÷ diameter.
Brass boilers: 20,000 × plate thickness × 2 ÷ diameter.
Steel boilers: 40,000 × plate thickness × 2 ÷ diameter.

Where single-riveted longitudinal joints are employed, divide the result by $\frac{1}{2}$, and for double-riveted seams divide by $\frac{3}{4}$.

To find the working pressure, it is assumed that the boiler will be safe if worked at a pressure which, if multiplied by a 'constant' or 'factor of safety' (a number arbitrarily fixed according to the ideas of the designer, and which varies from 6 to 10), will equal the bursting pressure. Therefore for a boiler which has a bursting pressure of 1000 lb., the working pressure may be either—

$$1000 \div 6 = 166 \text{ lb.}$$
$$\text{or } 1000 \div 8 = 125 \text{ lb.}$$
$$\text{or } 1000 \div 10 = 100 \text{ lb.}$$

The most usual factor for model work is 8, a lower figure being used only where the boiler is of the best design, and made of the best material and in the most workmanlike manner.

When it is required to find the plate thickness for a known diameter of boiler the following formula may be used, an allowance for deterioration from rusting being made where steel is employed:—

$$\text{Thickness in inches} = \frac{D \times WP \times F \times R}{S \times 2},$$

where

S = Strength of material (25,000 copper, 20,000 brass, 40,000 steel),
WP = Working pressure in lbs. per sq. in.,
F = Factor of safety (6 to 10),
R = Allowance for riveting ($1\frac{1}{3}$ for double riveting, 2 for single),
D = Diameter of barrel in inches.

Flat surfaces of over 3-in. area, where the plates are of about the same thickness as the shell, should be stayed with screwed stays, the total ultimate tensile strength of which should equal the area of the plate to be stayed × one and a half to twice the working pressure of the boiler. Allowing for the threads,

screwed copper stays of the following diameters will each support—

$\frac{1}{8}$	in.	225	lb.	copper or brass stays, B.A. threads.	
$\frac{5}{32}$	„	300	„	„	„ „
$\frac{3}{16}$	„	400	„	„	„ „
$\frac{1}{4}$	„	500	„	„	„ „
$\frac{3}{8}$	„	2730	„	steel stays, Whitworth threads.	
$\frac{1}{2}$	„	4800	„	„	„ „

Thus a firebox side measuring 6×4 in., the working pressure being 100, would require $2 \times \frac{6 \times 4 \times 100}{400} = 12$ stays $\frac{3}{16}$-in. diameter.

Stays in models up to 1 in. scale should be from $\frac{3}{4}$ to 1 in. apart. In larger engines using steel fireboxes the stays may be 2 to 4 in. apart; for instance, a 2-in. scale boiler with the sides of inner firebox 12 in. long $\times$ 9 in. high may be stayed by four $\frac{1}{2}$-in. steel stays, the plates being $\frac{3}{16}$ in. thick; the natural stiffness of these in itself helps to prevent the bulging of the firebox.

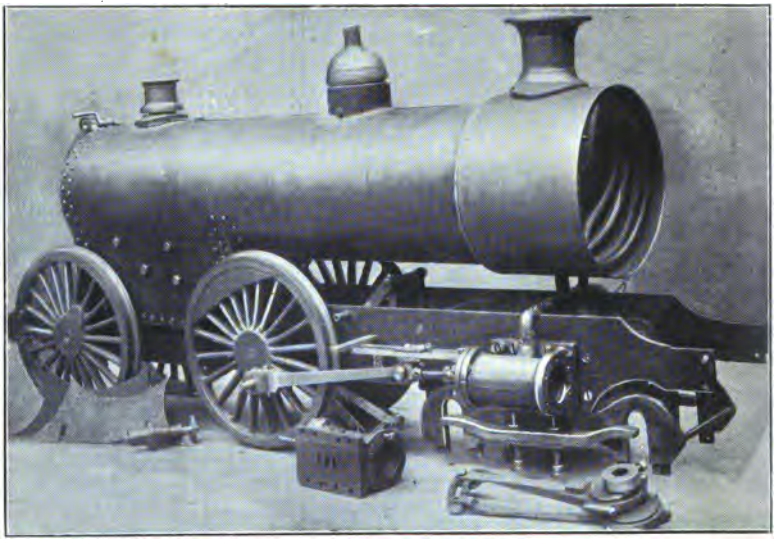


Fig. 48.—A Partly Finished $\frac{3}{4}$-in. Scale Model Express Locomotive.

CHAPTER V.

The Construction of Model Locomotives: Frames, Bogies, Radial Axleboxes and Trucks, and other Details.

The construction of a model locomotive is a task very often lightly entered upon and just as often laid aside uncompleted, and in preparing the drawings for a model to be made at home, the resources of the workshop, the cost and the skill available, all have to be considered. The size of the model it is desired to make will also influence the design and construction. Where no great amount of time is available and the kit of tools is small, the best policy is to choose one of the simpler designs given herein; but should a large model be imperative, smaller types of locomotives (*i.e.* tank engines) are to be recommended.

As a general rule the copying of a given prototype—whether it be a G.N.R., L. & N.W.R., or Midland engine—will create certain difficulties. Invariably, the writer has found that adherence to the detail and external outline of any original has rendered the job more complicated, and therefore costly. It is undoubtedly easier in designing to consider oneself freed from restriction in the matter of prototypes; as under such conditions, whilst it is, of course, always well to keep to the general dimensions common to locomotive practice and also to see that the appearance of the model will turn out to be pleasing and realistic—exteriors will, and should be, moulded by the constructive requirements, as in larger engineering work.

Many, however, prefer to model some well-known class of locomotive, and here again the question arises, How far shall the copying of the original extend? If unlimited resources (other than

monetary) are the assets of the maker, the author's advice is to build the engine, both externally and internally, as much like the original as is possible, altering only to suit practicable considerations of manufacture or design.

Where the model engineer desires a reliable working model, the component parts should be comparatively simple and the locomotive need only be to scale externally. Everything that is hidden, or needless from a pictorial point of view, may be omitted or modified.

For instance, frames need not be shaped in accordance with those of the prototype where they are not seen; cylinders and motion may be of very different design and construction; the boiler can be radically altered so long as the external dimensions are adhered to; indeed, the object of this volume chiefly lies in giving some idea as to how much it is advisable and necessary to modify in the construction of a perfect *working* model locomotive. Otherwise, any of the standard works on the locomotive should suffice.

Frames in the smaller models, say those to $\frac{5}{8}$-in. scale and smaller, may be of sheet brass. Small quantities of this material are readily obtainable, and it will be found very easy to work. It may be procured in strip form, and rolled or hard brass should be asked for.

The following thicknesses have been found most suitable for model locomotives. Where hornblocks are not used, the thicker material should be employed:—

	Brass.	Steel.
$\frac{7}{16}$-in. scale; thickness	$\frac{1}{20}$ in.	$\frac{1}{24}$ in.
$\frac{1}{2}$ " "	$\frac{1}{16}$ "	$\frac{1}{20}$ "
$\frac{9}{16}$ " "	$\frac{5}{64}$ "	$\frac{1}{16}$ "
$\frac{5}{8}$ " "	$\frac{5}{64}$ "	$\frac{1}{16}$ "
$\frac{3}{4}$ " "	$\frac{3}{32}$ or $\frac{7}{64}$ in.	$\frac{5}{64}$ in. or $\frac{3}{32}$ in.
1 " "	...	$\frac{3}{32}$ " or $\frac{1}{8}$ "
$1\frac{1}{2}$ " "	...	$\frac{1}{8}$ " or $\frac{5}{32}$ "
2 " "	...	$\frac{3}{16}$ " or $\frac{7}{32}$ "

Soldering *is* possible with steel plate, but brass joins very much more readily, and as in the tinier engines, parts are commonly affixed to the frames with solder in addition to screws or rivets, brass is invariably adopted. The frames of $\frac{7}{16}$ and $\frac{1}{2}$-in. scale

models of the simpler type may be made of tinned steel (or iron) plate of the thicknesses given; this material of course takes solder as readily as brass. The buffer planks may be of the same material as the main frames, and are best attached with angle plates and screws or rivets, this depending on whether inside or outside cylinders are employed, it being usually necessary in the former types to make this portion of the frames removable for purposes of piston packing and repair.

Wooden buffer planks are to be recommended for small models, as the engine may be more comfortably handled than one in which metal is used throughout. Of course for solidity's sake—if the frame of the engine is not considerably strengthened by other parts—a metal buffer beam placed behind the wooden one should connect the two main frames rigidly together.

As will be seen in the designs contained in these pages, stretcher plates of the same material as the frames are commonly used to

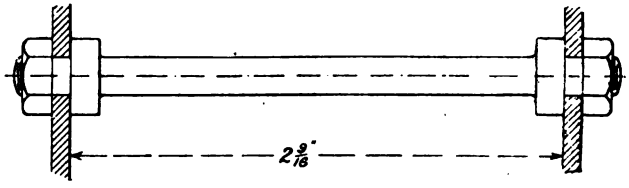


Fig. 49.—Turned Frame Stretchers.

transversely connect the main frames together and to stiffen the whole structure. In model work where these stretchers fulfil no other duty (such as that borne by the transverse plate behind the cylinders known as the 'motion plate') then the builder will find the turned distance bolts or frame braces shown in fig. 49 serve just as well. The writer has employed these in models of all scales and finds them quite satisfactory. It is easier for the amateur to turn these bolts to the right length over the collars than to flange a steel plate truly square in all directions, or to prepare a pattern and finish a casting.

Cast brass (or gun-metal) is sometimes used for main frames, but as a rule the material is not worth the amateur's consideration; it is very suitable where models are to be made in bulk commercially. Lugs for affixing footplates, and also hornblocks,

may be cast in position, thus saving a considerable amount of labour. However, the pattern-making necessary will usually deter the maker of a single engine from adopting this course.

To test frames for squareness, the lengths and widths being found correct, a rule or other measure should be stretched across diagonally, and if the structure is not truly rectangular in plan, the lines A B and C D will be of different lengths, as the sketch fig. 50 will show.

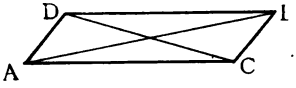


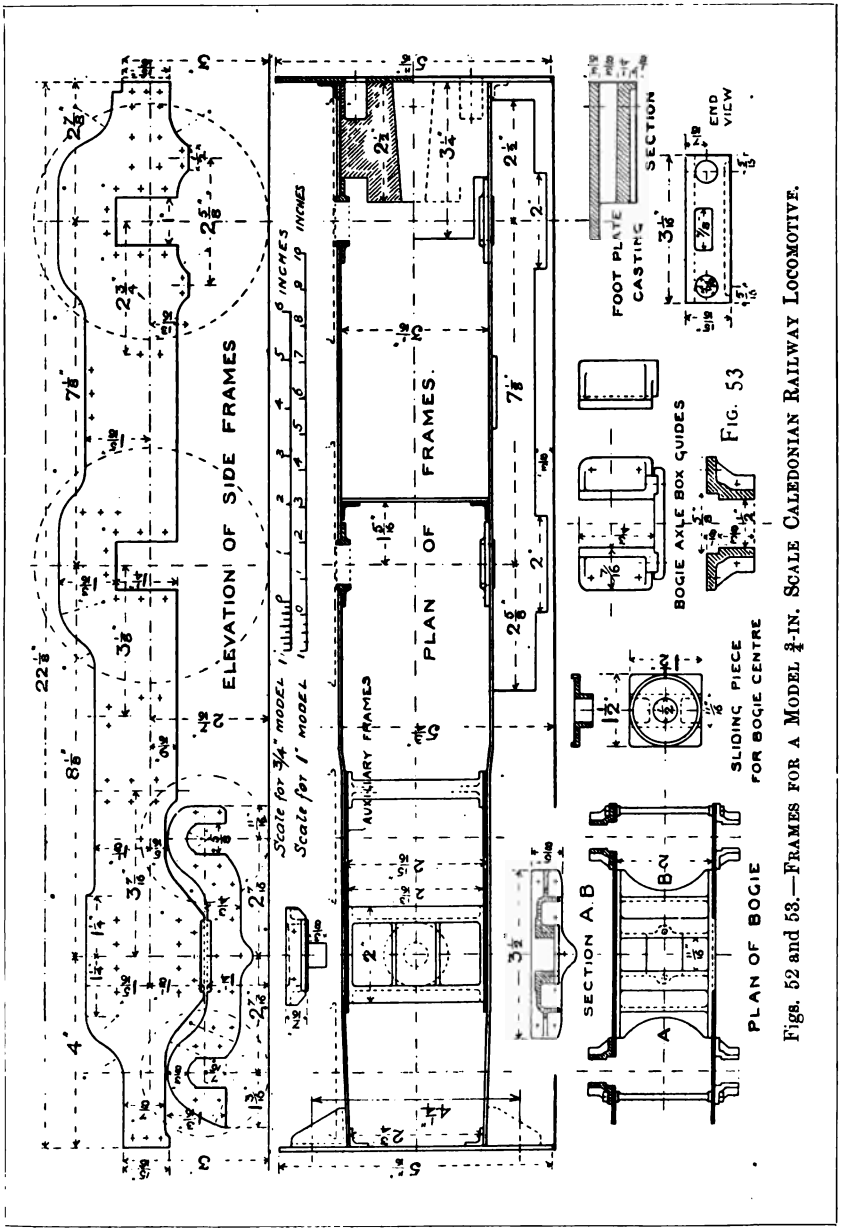
Fig. 50.

All centre lines should be marked clearly on frames, more especially those relating to cylinders and motion, and the usual method of 'centre popping' at intervals along these lines is advisable, so as to prevent the total obliteration of the marking.

In the accompanying detail drawing the frames for a model $\frac{3}{4}$-in. scale 'Dunalastair' Caledonian Railway locomotive, designed by Mr. E. L. Pearce, are shown. Here the prototype is very closely followed and a plate stretcher is employed in the front of the firebox, a cast footplate being adopted as in the original. The frames should be cut out of mild steel sheet, $\frac{1}{16}$-in. thick. The outline of the two frames should be carefully set out on a piece of steel 23 in. long × 10 in. wide. Mark the centre of plate at each end, and at a distance of 2 in. each side of this scribe two parallel lines the full length of plate; these will be 4 in. apart, and will be the centre lines of cylinders and coupled axles, from which all the dimensions for the varying depths of frame are given. At right angles to this the centres of the cylinders and of the driving and trailing axles should be marked off. By setting out the two frames at the same time with the top edges towards the centre of the plate, all the centre lines at right angles to the length can be scribed across the two frames at once.

The centres from which the various curves are struck are shown by a black dot; and the centres of most of the holes for rivets, screws, or bolts, used in fixing the axlebox guides, cross frames, and cylinders, are shown by a small +.

When the outline is complete, holes should be drilled all round the outside, clear of the line, the plate put on an anvil, and the metal cut through with a hammer and cold chisel. Then drill


ELEVATION OF SIDE FRAMES
PLAN OF FRAMES.
AUXILIARY FRAMES
Scale for 3/4" MODEL
Scale for 1" MODEL
0 1 2 3 4 5 6 INCHES
0 1 2 3 4 5 6 7 8 9 10 INCHES
SECTION A.B
PLAN OF BOGIE
SLIDING PIECE FOR BOGIE CENTRE
BOGIE AXLE BOX GUIDES
FOOT PLATE CASTING
SECTION
END VIEW

Figs. 52 and 53.—Frames for a Model ¾-in. Scale Caledonian Railway Locomotive.

holes $\frac{1}{8}$ in. diameter at several points along the two frames, and rivet them together with copper rivets, first seeing that the centre lines, which should be outside, coincide at the edges. The edges can then be filed down together to the exact outline, and the holes marked out for rivets or screws can be drilled through the two plates at once.

The axlebox guides, footplate casting, motion plate and bogie-pin casting, should all be cast in gun-metal, and the holes in them will be drilled $\frac{3}{32}$ in. diameter for tapping $\frac{1}{8}$-in. Whitworth, the screws being put in from the outside.

It will be noticed that the frames are set in near the motion plate to give more lateral play to the bogie wheels, and are further set at angles in front of the cylinders for the same purpose.

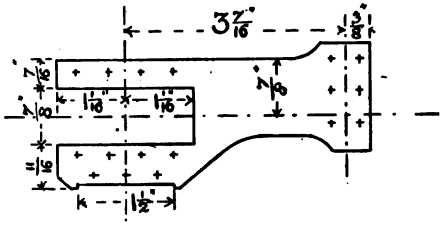


Fig. 51.—Auxiliary Frame.

The cylinders and motion plate, slide bars, etc., are in this design carried on an auxiliary frame (shown in fig. 51) which is bolted to the main frame, and therefore can more easily be erected and readily removed from the main frames for packing or repairs without upsetting the relative alignment of these important portions of the engine. This arrangement is certainly advantageous, where inside cylinders with four bars and valves between are employed.

The cylinders in small engines—more especially single-cylinder engines where the ordinary commercial type of cylinder is adopted—may be fixed to a flanged horizontal stretcher passing from side frame to side frame as shown in the single-cylinder design, the outer end of the slide bar being supported by a similar but smaller stretcher, or to a turned frame brace, or left without any fixing at this end whatsoever (see page 255).

The hornblocks or axle guides for the Caledonian engine shown in fig. 54 are of the orthodox design, the hornstays—which, by the way, are sometimes erroneously called 'keeps'—being of cast brass, lipped at ends to render the frames less weak at the axlebox opening, and secured by screws to the guides (see figs. 53 and 54).

The rear end of the frame is fitted with a cast footplate. This is used very often to add weight to a four-coupled bogie engine, and to keep the centre of gravity well back, as in these engines it will generally fall in front of the driving wheel, when a greater weight than is advisable will be thrown on the bogie, and the adhesive weight considerably lessened. This casting is cored for drawbars and buffers.

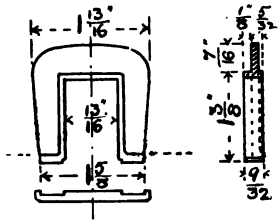


Fig. 54.—Hornblocks.

In contradistinction of the more complete method of building the frames adopted in the model just referred to, fig. 55 shows the frame of a model ten-wheeled tank

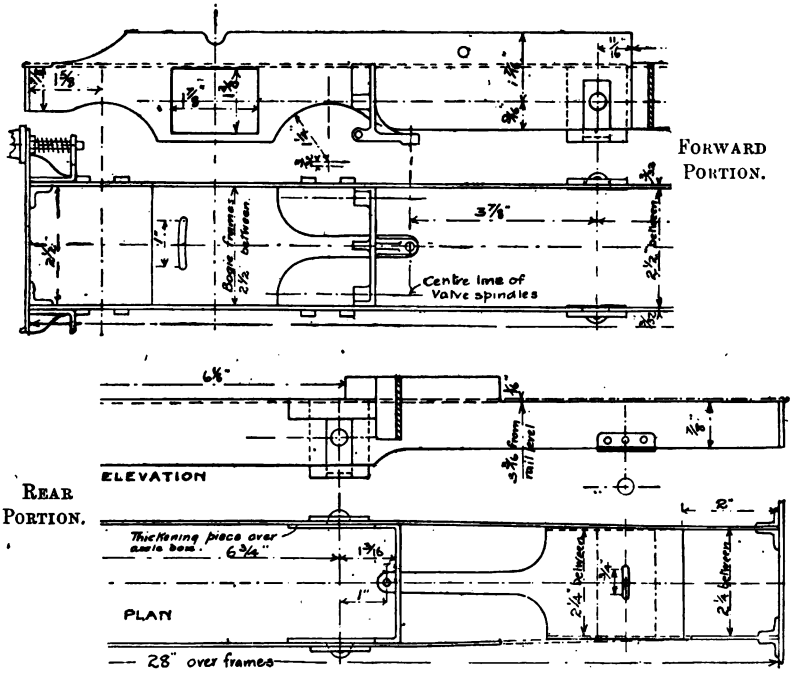


Fig. 55.—Framing of a Model ¾-in. Scale Ten-wheeled Tank Locomotive.

locomotive further described on page 268. The frames here are of $\frac{3}{32}$-in. mild steel plate, and are arranged with as few deviations from the straight line as possible.

To save pattern-making and to simplify construction, the axlebox guides are simply pieces of ⅛-in. plate riveted on to the main frame, the hornstays being castings or pieces of stout angle brass shaped as shown in fig. 56.

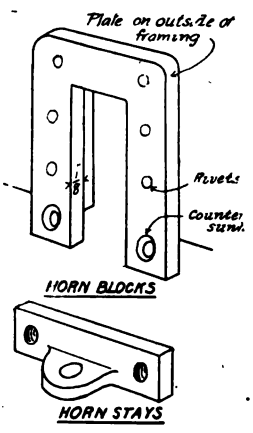


Fig. 56.

The bogie wheels being the scale equivalent of about 3 ft. in the real engine, it is possible, in this design, to cut away the frames and allow both pairs of bogie wheels to swing under them, as recommended in Chapter II. Also, to give sufficient lateral play to the trailing radial truck, the frames are set in behind the rear-coupled wheel. The motion plate is cast brass, and carries the pivot of the 'Bissel' type leading bogie. A hole is cut in the frames for the face of the connected steam chest to pass through, and the leading guard iron forms also an angle bracket to take the thrust of the buffer spring.

One of the chief points in this design is the method of obtaining the maximum width for the firebox. A shallow firebox being all that is necessary, the frames are cut down to footplate line behind the driving axle, the foundation ring of the boiler resting on the top of the frames as shown in fig. 57 and Plate IX.; and to obtain the greatest length of firebox without unduly increasing the coupled wheel-base, the back plate of the boiler extends over the trailing axle. This of course, with large driving wheels, cuts down the depth of the frames at the point X in fig. 57 to a dangerously weak degree, and to reinforce the frames the axlebox guide is carried over the top of the opening in one piece and a plate riveted on the inside as shown in upper part of the sketch. With the strength given to the structure by the hornstay, this otherwise weak point is made quite as strong as it would be if it followed the more ordinary practice. In fact, it may be said that the plate frame is changed to the American 'bar' system at the portion under consideration.

Axleboxes form a feature in the construction of a model locomotive in which there is a very great possibility of modification.

These portions of a real locomotive receive a considerable amount of attention, as they are among the parts most likely to give trouble by heating, owing to the large loads carried per square inch of surface. However, these difficulties do not enter into model locomotive practice.

Figs. 58 and 59 show coupled and bogie axleboxes for the $\frac{3}{4}$-in scale Caledonian model already referred to, and which very closely follow those of the prototype. Separate keeps are intended, and the axleboxes have flanges on both faces, inside and outside the guides.

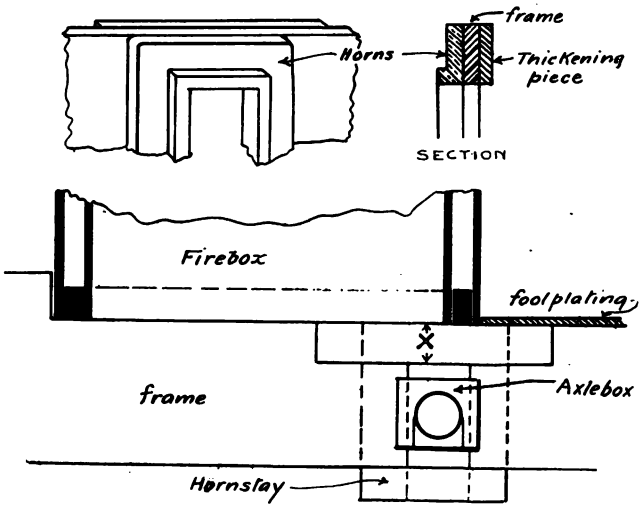


Fig. 57.

The spring pins are screwed into the keeps. This is suitable for model locomotives of small dimensions, but with larger engines of, say, 2-in. scale where a good deal of wear and tear will take place, to save any failure the springs should be attached to the axlebox by a pivoted link as shown in the L.T. & S.R. design (Plate VIII.) and on page 100, fig. 109A.

A simplified form of locomotive axlebox is depicted in fig. 60. This kind is eminently suitable for models of $\frac{3}{4}$-in. scale and under. Only one side is flanged, the two axleboxes together giving the necessary lateral control. With, say, $\frac{1}{32}$ in. sideplay this type of box is very much more free to rise and fall to the surface of the

road, and does not bind in horns with an excessive up-and-down movement, especially if the bearing face of the flange is slightly rounded at the top and bottom faces of the shoulder, as indicated by fig. 61, than the usual kind with two flanges.

Axleboxes may be made with only one flange and fitted to frames having no hornblocks. A bearing having a spring pin

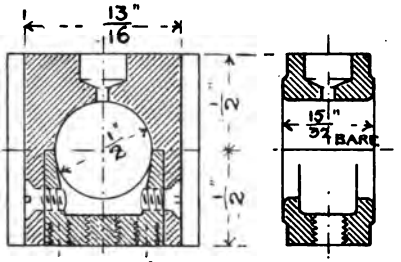


Fig. 58. — Driving and Coupled Axleboxes, $\frac{3}{4}$-in. Scale.

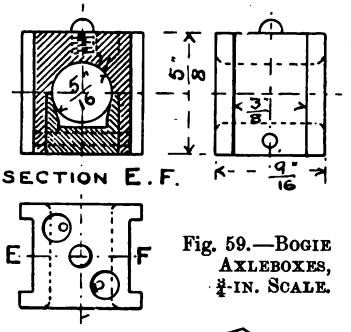


Fig. 59.—Bogie Axleboxes, $\frac{3}{4}$-in. Scale.

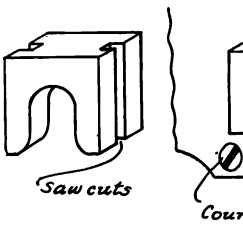


Fig. 62.—Axleboxes without Keeps.

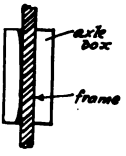


Fig. 61.

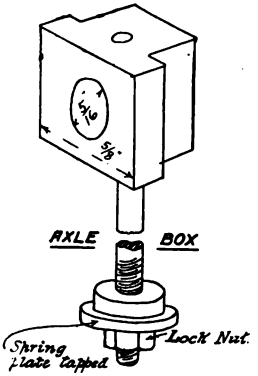


Fig. 60.—Simple Loco Axlebox.

underneath it, must be placed on the axle (in inside-framed engines) before the wheels are attached; but for carrying wheels axleboxes can be made without any keep whatever, the hornstay preventing the wheels falling from the frames altogether. This arrangement provides plenty of 'drop' for the wheels, which is essential in small engines running at high speed over comparatively rough roads. The sketch, fig. 62, also shows another method of fitting axleboxes in the frames. Where frames are about $\frac{1}{16}$-in. thick a saw cut

is made in the sides, and with a warding file cleaned out to size as shown. No hornblocks or other guides are necessary other than an oblong opening in the main frames and a hornstay.

An even simpler device is described in figs. 63 and 64. Here the axlebox is not provided with any flange, being placed between the wheel and the frame, in which a slot of the same width as the diameter of the axle has been cut. Axleboxes made in this way are suitable for models of $\frac{5}{8}$, $\frac{1}{2}$, and $\frac{3}{8}$-in. scales, and will be found a great improvement over the old-fashioned method of providing no bearing springs whatever.

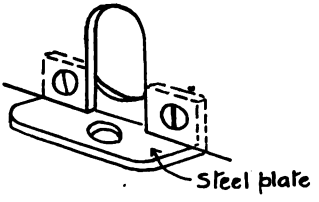


Fig. 63.—Slotted Frames and Hornstay.

Bogies.

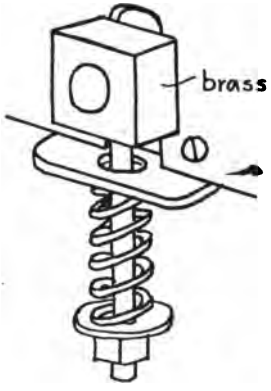


Fig. 64.—Axlebox in Position.

Before describing the various methods in which bogies are constructed, a few words as to the principles involved should not come amiss. A bogie is a wheeled carriage entirely separate from, but attached by a centre pin or pivot to, the main frame of the engine, and in locomotive work is generally supported on four wheels of small dimensions. The use of the separate truck gives flexibility to the wheel-base of the locomotive when it is passing over curves and crossings, but it must be distinctly understood that the fitting of a centre pivot, under the majority of circumstances, will not, alone, accomplish the required object. The accompanying fig. 66 (B), shows in plan what is likely to happen to an engine with a partly rigid wheel-base and a bogie with a centre pin only, if the leading wheel of the bogie truck and the coupled wheels keep the road. Diagram A shows the engine provided with a lateral sliding movement as well as a revolving movement, all the wheels keeping the road on a curve.

The sliding-box type of bogie is known as 'Adams' patent,' and

is in universal use. For model work it is the very best, and allows the utmost freedom of the locomotive on sharp curves. Another form which is suitable for models which are not intended to run over excessively sharp curves, and is much the same in action —with limitations—is the Bissel bogie (see fig. 67, C), which is pivoted some distance behind the rear bogie wheel—about halfway between the latter and following rigid wheel.

The diagram D, fig. 67, shows a method which may be adopted for single engines not expected to negotiate curves of comparatively small radii. A centre pivot only is used for the bogie

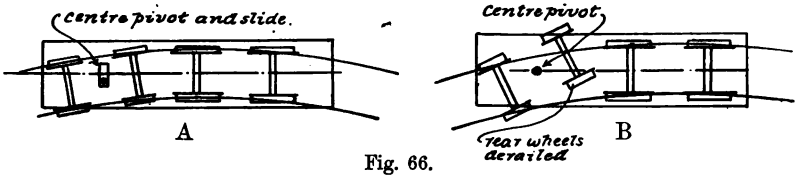


Fig. 66.

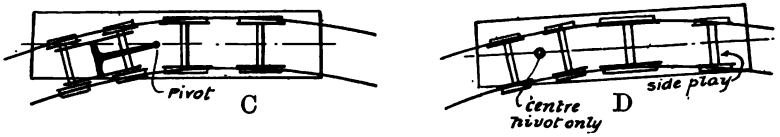


Fig. 67.

(the pin may be placed a trifle out of the longitudinal centre—a little nearer the rear bogie wheel), and the trailing wheel, which must not be a coupled wheel, should be given a certain amount of sideplay in the axleboxes. This sideplay allows the body of the engine to swing over in the direction of the curve, and renders the slide-block slot unnecessary.

For a high-class model the standard practice should be followed, suitable arrangements being given on pages 69 and 83, and Plates VII. and VIII., for the Caledonian and L.T.S.R. designs respectively. Both of these examples closely resemble that of the prototypes, and are also very much alike. The controlling of the lateral movement of the sliding box is accomplished by spiral springs. Fig. 69 shows a simplified form adapted more especially for the design for a model L. & N.W.R. type ten-wheeled tank locomotive included in this volume. No controlling spring is fitted, and the sliding box or pad

may be either as shown or have a circular boss (see dotted lines in plan of detail), according to the sharpness of the curves of the railway and the amount of sideplay required.

The cover of the steam chest forms the bogie pin casting in this design. This course may be adopted in many designs where the cylinders are directly over the bogie.

Fig. 68.—THE BOGIE FOR A MODEL LONDON AND SOUTH-WESTERN RAILWAY LOCOMOTIVE, MADE BY MESSRS. COATES.

(This view shows the parts separated, and the laminated side-controlling springs.)

Adams' type of bogies for small models of a simple character may be made by simply slotting the cross stretcher or bed-plate of the bogie to fit a centre pin attached to a similar plate on the main frames as shown in fig. 71, which more or less explains itself.

Another simple method is depicted in the accompanying sketch (fig. 72), and comprised in a design on Plate III. Controlling springs may be employed without much trouble, and no castings are required to be affixed across the main frames, two turned braces on which the pivot block slides being substituted. A cast bogie cross-frame is of course not absolutely essential.

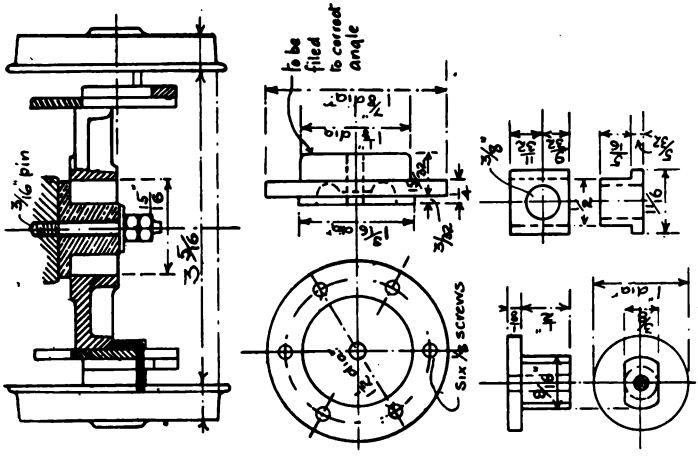


Fig. 70.—Cross-section and Details of Bogie and Axleboxes.

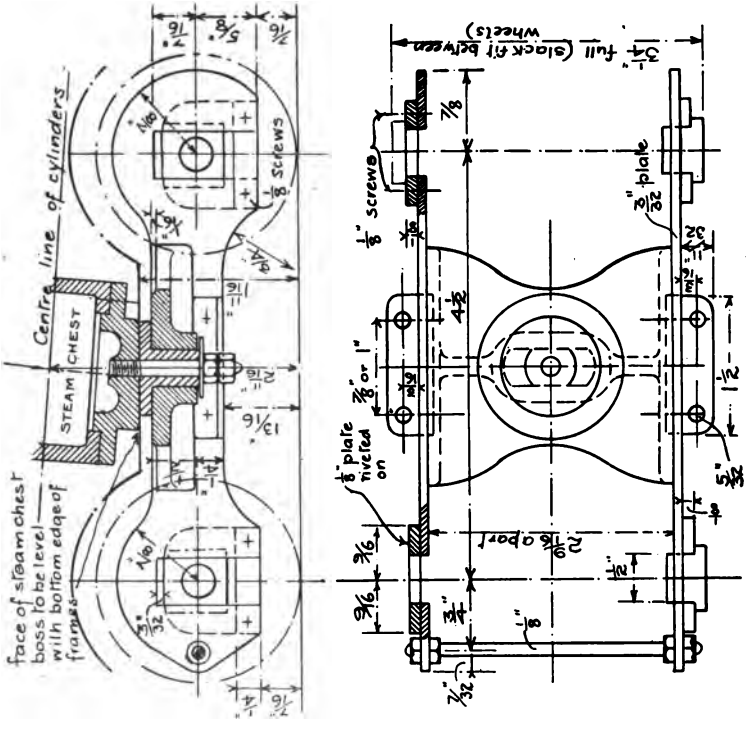


Fig. 69.—Plan and Sectional Elevation of an 'Adams' Bogie for a ¾-in. Scale Model.

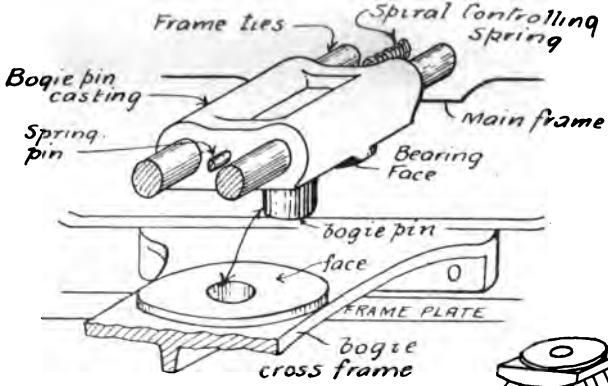
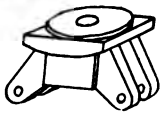


Fig. 72.—Modified 'Adams' Bogie with Controlling Springs.



Sliding Pad.

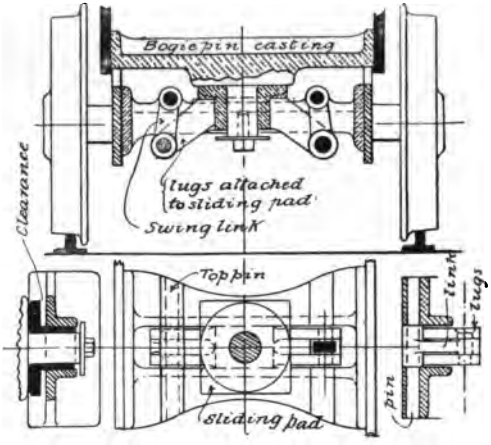


Fig. 73.—Swing-Link Bogie.

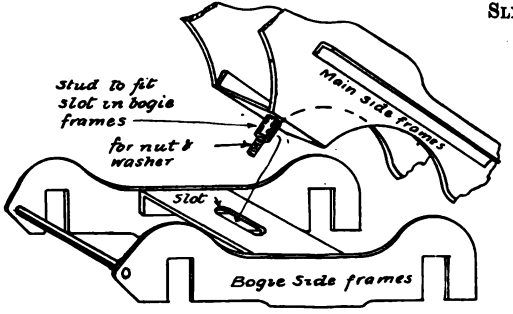


Fig. 71.—Simple 'Adams' Bogie.

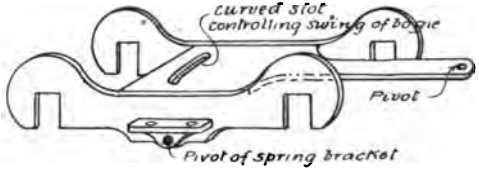


Fig. 76.—A Simple Bissel Bogie. (See photograph, fig. 76.)

On some railways it is the practice to control the lateral movement by slinging the bogie on links (see fig. 73), and this should work out very well for models. The links should be set in towards the centre at a slight angle. For bogies needing a considerable amount of sideplay the links should be as long as possible.

There are very many methods of arranging bogie attachments, but these must be left to the reader to work out for himself, and the question of suspension of the bogie wheels on springs proceeded with.

Tiny models may be built with bogies having no springs, the axles simply running in plain holes in the framing, a spiral spring or a comparatively large piece of india-rubber being placed

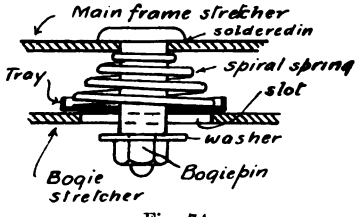


Fig. 74.

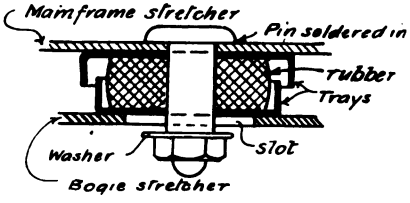


Fig. 75.

between the cross plates of the bogie and main frames respectively. An example of this method is shown in figs. 74 and 75, the rubber pad in the latter being protected by washers of tin. In the volute spring arrangement the lower tray prevents the spring fouling the slot and keeps it quite central. The best rubber is that used for cushions of india-rubber stamps used in offices, this material being cellular in structure.

Larger and more complex models should have better arrangements than these, and one giving the least trouble in manufacture, and generally the best results in running, is shown in the accompanying photograph (fig. 78).

Locomotive engineers in England are divided in the use of the equalising or compensating beam, both for bogies and rigid wheels; but where railroads are not so perfect as they are in this country, the equalising beam is universally employed. Model railways do not as a rule attain a proportionately high degree of smoothness, and therefore, for bogies especially, the equaliser is to be recommended.

The simplest form in which this can be applied is shown in fig. 77. Both the axleboxes and equaliser on each side are in one casting, the pattern being made as realistic as possible, and the slot in the frames is arranged to take the axles only. The compensating beam being pivoted only and having no springs, the bogie should be carried by one of the methods indicated in figs. 74 and 75.

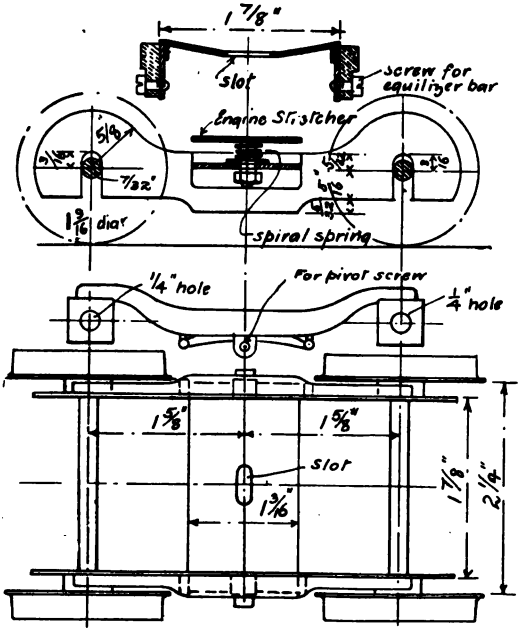


Fig. 77.—Simple Bogie for Model North-Eastern Railway Locomotive.

Fig. 76, which illustrates the construction of a Bissel bogie (see C, fig. 67) shows one method of supporting the spiral springs of an equaliser of this pattern by a pivoted bracket instead of by a fixed bracket as shown in the photograph, fig. 78, and in fig. 79. It will be noted that in the examples described by figs. 76, 77, and 78 no hornstays are necessary if the axleboxes and equalising beam are cast in one piece. So long as the bracket remains in place the wheels cannot drop from the frames when the engine is lifted.

Where the separate bracket is employed the wheels and axles can be removed from the bogie frame by simply unscrewing the pivot screw, otherwise if the bracket is fixed, the wheels on one side must be taken from the axles, as is the case in fig. 78. Where combined beams and boxes are employed the holes in the axleboxes should be drilled $\frac{1}{32}$-in. larger than the diameter of the axle.

If the axleboxes are run in guides in the orthodox manner, then separate beams are necessary, and fig. 79 shows this improvement, this drawing corresponding with fig. 69 already described.

Any pattern of axlebox may be employed, and the equalisers should be provided with rounded projections where they bear on

Fig. 78.—A 'Bissel' Bogie for a ⅝-in. Scale Model Locomotive.

the top of the box, or the latter fitted with a vertical stud engaging a corresponding hollow in the beam.

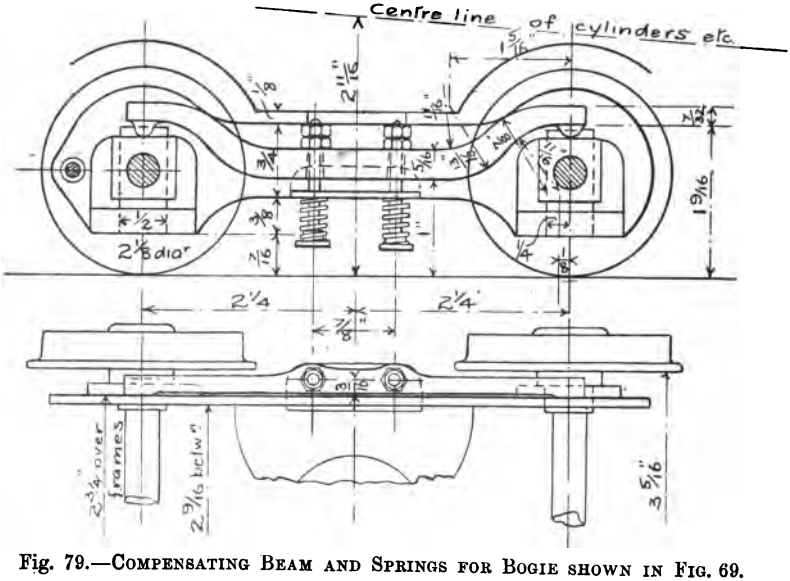


Fig. 79.—Compensating Beam and Springs for Bogie shown in Fig. 69.

The springs may be either laminated or of the spiral pattern. Spiral springs give greater life to the engine, and being more easy of adjustment, are to be recommended in every way. A solid equaliser may be also employed, in place of the usual built-up structure having laminated springs between the plates as shown in fig. 80, a design which on a working model is not advised for scales smaller than one inch to the foot, and even then it may be dispensed with in favour of a simpler pattern.

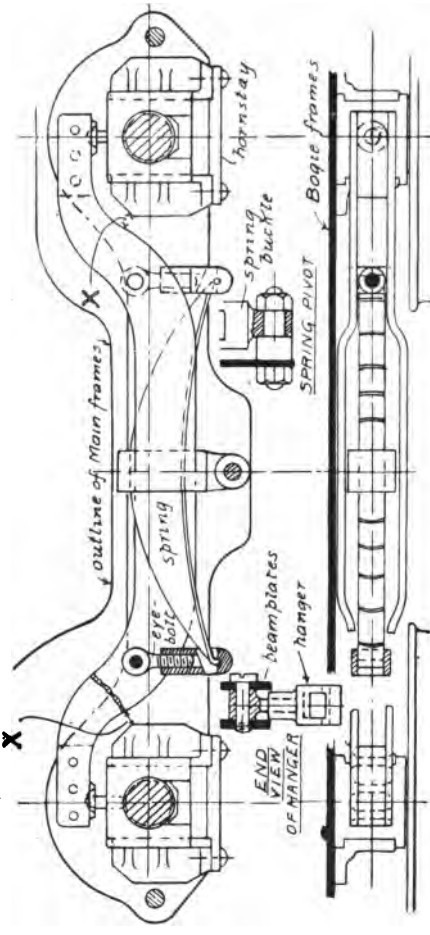


Fig. 80.—Compensating Beam and Bearing Springs for 1-in. Scale, L.T.S.R. Locomotive.

The buckle of the spring is carried in the latter instance from a heavy stud affixed to the bogie side plates. It should be noted, in setting out bogie arrangements, that sufficient clearance must be allowed at point X, fig. 80, for the rise and fall of the compensating beam. Here the axlebox guides are of necessity placed outside, and cannot very well be extended over the top of the opening in the side frames. Bissel bogies are very easily constructed from sheet material (see fig. 76) without the use of castings (except where a controller is employed). The pivot bracket may be attached to or cast with the motion plate (see fig. 55), the sketch (fig. 84) showing the bracket used as first mentioned and with the controlling gear

fitted. This gear, by the way, is not necessary in models smaller than $\frac{3}{4}$-in. scale.

Radial Trucks.

Single pairs of carrying wheels are very often fitted to the main frames in such a way that they can take up a radial position when the engine is running around a curve.

The simplest form of arranging this to a model locomotive is indicated below (fig. 82). The truck is pivoted from a convenient bracket or bar at P, the axles being fitted into plain holes in the upturned portion A. Spiral bearing springs intervene between the main frames and the pony truck as illustrated in the sketch and in fig. 358, page 255. The nuts on the spring pin prevent the truck falling away from the engine when it is lifted up from the rails.

The axlebox may be separate from the bed-plate of the truck; the elevation of this portion in relation to the main frames is illustrated in fig. 81, sufficient distance being allowed between the axle and the main frames for the maximum compression of the spring, the lateral swing of the truck being controlled by the upright bearing piece, which should strike the frame and prevent further movement of the wheels as shown at D in fig. 82.

Fig. 81.

A constructively superior arrangement on this plan is illustrated in the L.T.S.R. tank locomotive (Plate VIII.). Here the pivot end has a ball-and-socket joint, for purposes of increased strength, and the other is prevented from rising too high and fouling the main frame by the transverse stretcher just behind the wheel centre, and from falling away by the pronged collar which at its centre is affixed to a squared stud, attached to the aforesaid stretcher, passing through a slot in the bed-plate of truck. The prongs should not quite reach each side frame, the distance between them regulating the play of the truck, and to control the arrangement spiral springs of the same length may be placed one on each prong as shown.

A construction which may be considered stronger is to allow no vertical movement to the truck (*vide* the design for the L. & N. W.R.

ten-wheeled tank, Plate IV.) shown in the accompanying detail drawings (fig. 83). The controlling arrangement used for the Bissel type bogie (fig. 78) may be employed, the bearing spring gear being wholly contained in the pony truck. The perspective sketch (fig. 85) shows a slight variation from the drawings above referred to, sheet material being intended, and

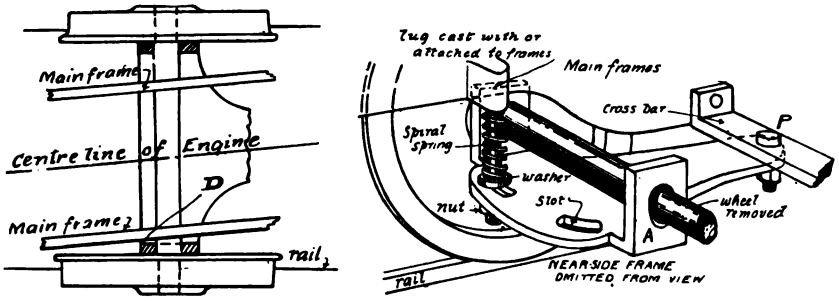


Fig. 82.—A Simple Pony Truck.

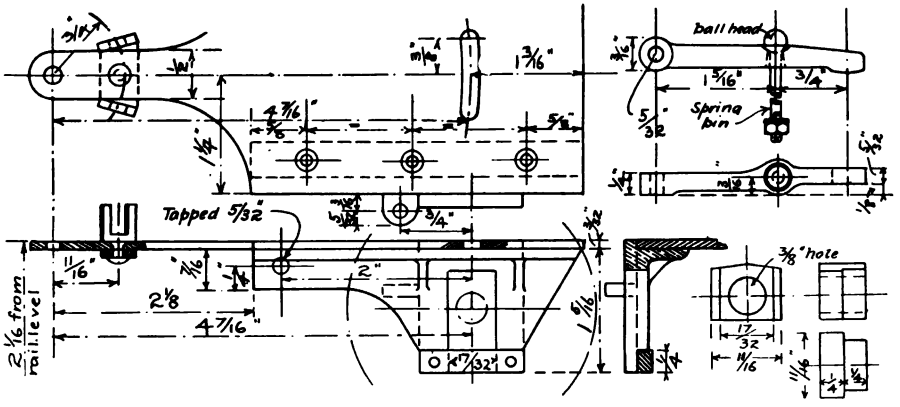


Fig. 83.—A Pony Truck for a ¾-in. Scale Model.

the lug on the end of the spring bar being replaced by a projection on the top of the axlebox. A modification of the usual form of radial axlebox is shown in fig. 86. It consists of two curved slides with correspondingly curved axleboxes, with a plate at the top and bottom rigidly connecting each. The controlling gear is very clearly explained by the sketch, and needs no further description. One point which must not be overlooked with this type of radial

axlebox is, that if one wheel is depressed and the other wheel raised by the inevitable unevenness of the track, to any considerable extent, the axlebox will bind; indeed, if the box were made what is called a 'working fit' in the slides, it would be found incapable of even the slightest tilting movement in a vertical direction. Therefore, as it is in the real locomotive, the boxes must be made a very slack fit in the guides. This seems to be the chief disadvantage of the arrangement, which, by the way, should not in any case be fitted to engines under $\frac{3}{4}$ in. scale. To remedy its faults, the writer suggests the arrangement shown in figs. 87 and 88. The curved frame is here fixed as regards vertical movement in the slides, small

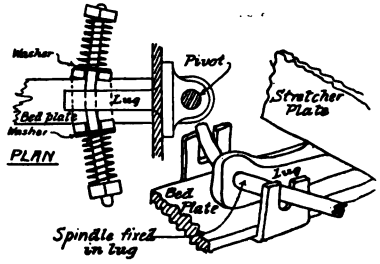


Fig. 84.—Controlling Gear for 'Bissel' and Pony Trucks.

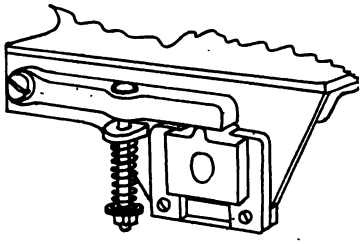


Fig. 85.—Sketch of Bearing Spring.

bearings capable of up-and-down movement and connected to the springs working in the frame. Freedom of action is essential, however, in all parts of the arrangement; and where the work is not done with machine tools, the grinding of the frame in the curved slide should secure the desired result. To save screwing the top and bottom plates of the curved frame, these may be silver-soldered to the axlebox guides (see fig. 88).

Buffers and Drawhooks.

Buffers for model locomotives should, as a rule, be fitted with springs, and, wherever possible, steel (or german silver) should be used for the heads. Two kinds of buffers are common to British locomotive practice (see A and B, fig. 89), each railway company having its own particular pattern. The standard distance between

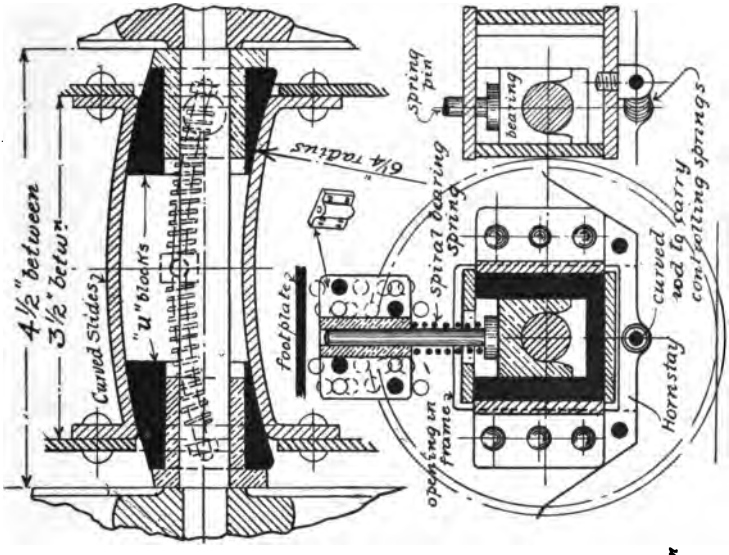
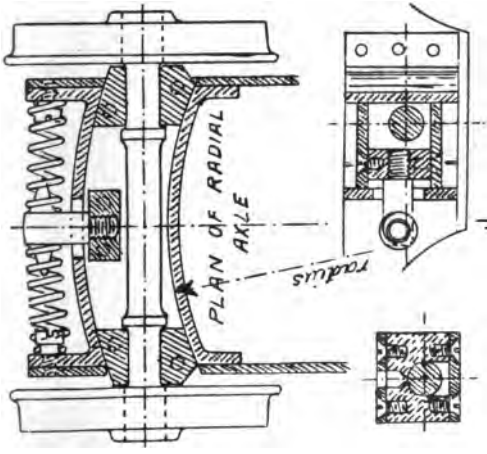


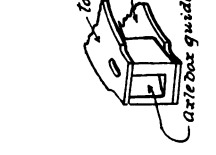
Fig. 87.—An Improved Radial Axlebox with Separate Bearing.



Section of Axlebox.

Section through Centre Line.

Fig. 86.



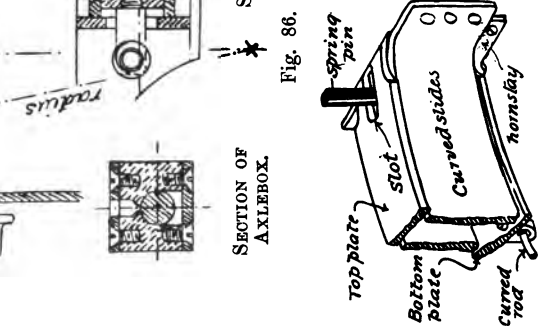
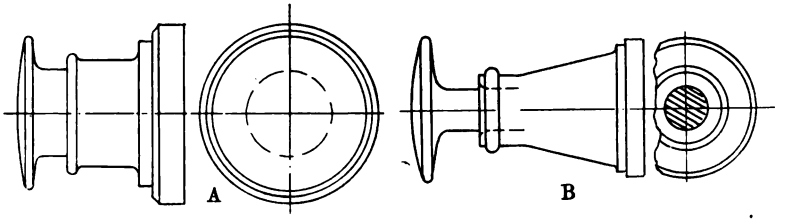


Fig. 88.—Details of Improved Radial Axlebox.

buffer centres is 5 ft. 8 in., and from the rails buffer and drawbar centres measure 3 ft. 5½ in.

The type of buffer B is, in small models at least, best arranged with the spring behind the buffer plate, as shown in fig. 91. The



LONDON AND NORTH-WESTERN RAILWAY. GREAT CENTRAL.

Fig. 89.—BUFFER TYPES. (Scale, ¾-in. to the foot.)

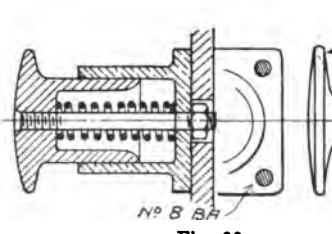


Fig. 90.

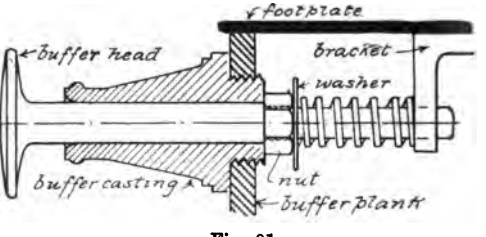


Fig. 91.

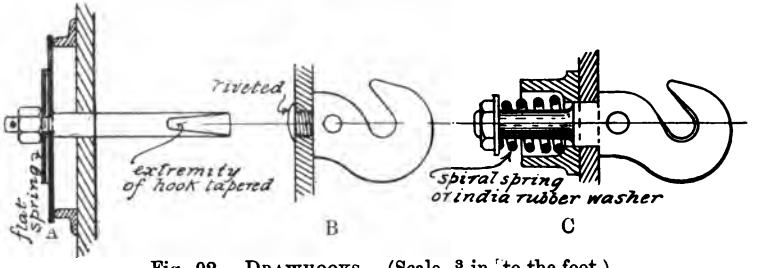


Fig. 92.—DRAWHOOKS. (Scale, ¾-in. to the foot.)

other kind may contain a spiral spring in the casting, after the usual manner, as illustrated in drawing, fig. 90.

Drawhooks for small models need only be screwed and riveted into the buffer plank. In heavier engines, however, one of the two methods shown at A and C in fig. 92 may be employed with advantage.

Side chains are often fitted to the buffer planks of real loco-

motives, and besides adding to the appearance of a model to which they are fitted, they may be made to fulfil other purposes, as in the example on Plate III., where the eyebolts of the rear side chains serve to hold up the auxiliary spirit tank, the shanks passing through the buffer plank into tapped holes in the blocks on top of the cylindrical reservoir.

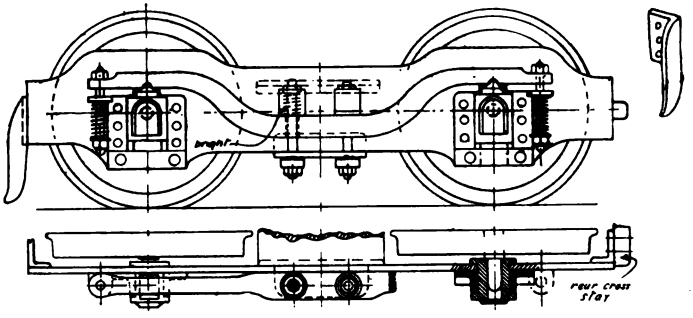


Fig. 93.—A Design for a Bogie with Outside Framing.

CHAPTER VI.

Wheels, Axles, Crank Axles, and Bearing-spring Arrangements.

Wheels.—The size and kind of wheels employed on a locomotive are determined by the general design. They may be divided into three classes:—

(1) Driving wheels.
(2) Coupled wheels.
(3) Carrying wheels.

Wheels in actual practice are made in two portions, the tyres being separate from the centres and different materials being employed. Coupled wheels are of course of exactly the same diameter as the driving wheels, the chief difference between the two being in the disposition of the balance weights.

For outside-framed and inside-cylinder single engines a circular boss (or knave) is usual, whereas the wheels of inside-framed outside-cylinder locomotives and inside-framed coupled engines have pear-shaped bosses to take the crank pins.

Great care should be taken in proportioning the wheels of a model locomotive, as nothing will more easily spoil the appearance of an engine than wheels of inferior design; for instance, an insufficient number of spokes, spokes of incorrect section, tyres too thin or too thick, and balance weights placed in impossible positions.

The spokes should not be too square in section, and should flow into the boss and rim of a wheel with suitable radii and flowing curves. To save expense in moulding, patterns have generally to be made with the spokes and rims tapering to allow of an easy

withdrawal from the sand (see fig. 94). However, the front of the pattern may almost exactly conform to the profiles of the finished wheel, the filing up of the spokes being done at the back, as is indicated by the shaded part of the section.

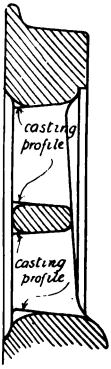
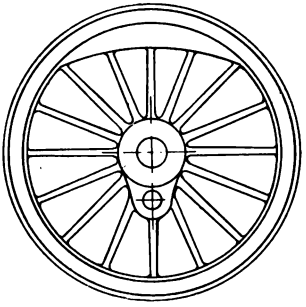
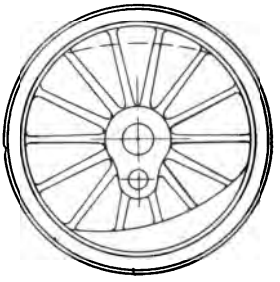


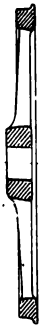
Fig. 94.

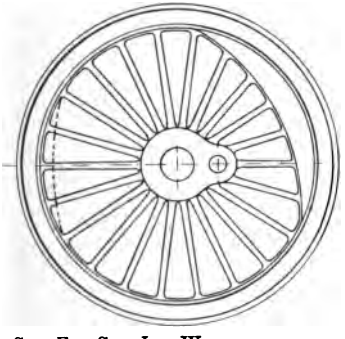


SIX FT. WHEEL FOR OUTSIDE CYLINDERS.

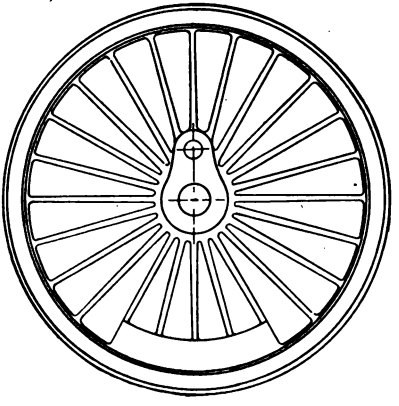


FIVE FT. SIX IN. WHEEL FOR INSIDE CYLINDERS.





SIX FT. SIX IN. WHEEL FOR INSIDE CYLINDERS.



EIGHT FT. 'SINGLE' WHEEL FOR OUTSIDE CYLINDERS.

Fig. 95.—TYPICAL LOCOMOTIVE DRIVING WHEELS.

(Dotted lines indicate balance weights for coupled wheels. Scale, ¼-in. to the foot.)

The best rule for finding the number of spokes in a locomotive wheel is to multiply the diameter (in feet) of the wheel of the prototype by 3 for small wheels and $3\frac{1}{4}$ for larger wheels, making the total up to an even number. Taking the $\frac{3}{4}$-in. scale Caledonian design on Plate VII, as an example, the driving and

coupled wheels are $4\frac{7}{8}$ in. in the model, which works out to 6 ft. 6 in. in the prototype. Therefore $6\frac{1}{2}$ ft. $\times 3\frac{1}{4} = 21\frac{1}{8}$ spokes, the nearest even figure being 22. This is the number used in the prototype. The carrying (bogie) wheels of the original engine are 3 ft. 6 in. diameter. Multiply this by 3 and the result is $10\frac{1}{2}$. Ten spokes are employed in the prototype.

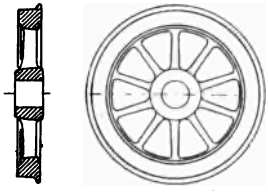


Fig. 96.—Three Ft. Six In. Bogie Wheel.

The cross-section of the spokes of a real locomotive varies according to the material used. Cast-iron wheel centres (which are not common) sometimes have spokes of I section. Wrought-iron wheels are provided with spokes slightly more

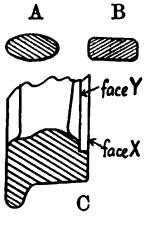


Fig. 97.

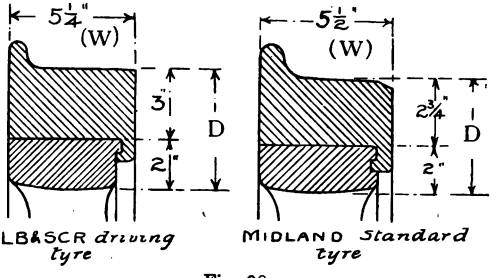


Fig. 98.

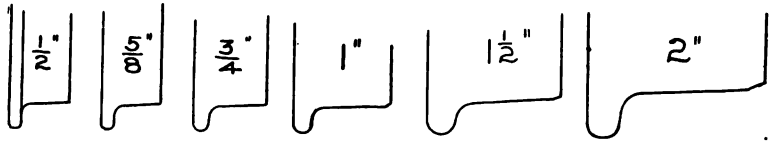


Fig. 99.—Full Size Tyre Sections for Models.

rectangular than those cast in steel; see A and B respectively in fig. 97 for the wrought-iron and cast-steel spoke sections. Wheel 'centres' of cast steel are now universally used in large practice, and have a very fine appearance. At the ends of the spokes where they join the rim, the section should measure the scale equivalent of about $3\frac{1}{2} \times 1\frac{3}{4}$ in. and at the boss about $4\frac{1}{2} \times 2\frac{1}{4}$ in. or $5 \times 2\frac{1}{2}$ in.

To enable the model maker, who does not as a rule use a separate tyre, to determine the depth of the rim, the above sections of

the standard rims and tyres used by two railways are included herewith.

For a $\frac{3}{4}$-in. scale model, therefore, the depth (D) should be about $\frac{5}{16}$ in., but the best width for models of $\frac{5}{8}$-in. scale and above is a scale equivalent of 6 in. instead of $5\frac{1}{2}$ in. The dimensions (W) will be by this rule, $\frac{3}{8}$ in. for $\frac{3}{4}$-in. scale; $\frac{1}{2}$ in. for 1 in., and $\frac{3}{4}$-in. for $1\frac{1}{2}$ in. scale models. For $\frac{1}{2}$-in. scale locomotives the tyre should be $\frac{5}{16}$ in. or $\frac{9}{32}$ in. wide; that is, if the engine is to do a fair amount of running over points and crossings.

It will be noticed, by reference to the drawings of standard tyres, that the driving wheels flanges are made thinner than those of the carrying or coupled wheels. This is to to allow a greater amount of sideplay and to prevent strains on the crank axle during the passage of the engine over points, check rails and crossings. The face of the tyre of a model wheel should always be turned in section as illustrated at C in fig. 97, to give the observer the idea that the rim and tyre are not of one piece of metal.

The balance weights will look better if made flush with the face Y and not with the face of the spokes or the tyre, unless either of these courses are adopted in the prototype being modelled. A good appearance is gained where the counterweights project slightly from face Y. This projection, however, should not extend so much as to bring the face of the weight into a plane parallel to the face of the tyre. Where, as in inside-cylinder engines it is required to obtain the maximum width between wheel seats (and therefore between main frames), it is common practice to recess the back of the wheel at the boss, also coning the front face of the spokes. The front of the boss of the wheel will then extend outwards a considerable distance beyond the tyre face, in some instances often as much as half the width of the tyre (see fig. 100). This method, besides increasing the available space for cranks, eccentrics and bearings, lends an interest to the appearance of the wheel, and the coning of the front face and the outward extension of the boss may be recommended in all model locomotives.

Reverting to the subject of tyre sections, the profile of a tyre will become less a scale reproduction of the real thing as the model becomes smaller in size. For instance, premising 1 in. as the

thickness of the flange of an actual locomotive and 1 in. as the depth, these dimensions in a ½-in. scale model work out to $\frac{1}{24}$ in. and $\frac{1}{20}$ in. respectively, and it will be seen that a very good railroad would be necessary to ensure the safe running of a model locomotive provided with flanges of these dimensions. In practice, the flange depth should never be less than $\frac{3}{32}$ in., ⅛ in. being a more suitable size, and to lengthen the life of the wheels the thickness should not be less than $\frac{1}{16}$ in.

A set of tyre sections drawn to full size is illustrated in fig. 99, from which templates may be made for use in turning wheels of ½-in. to 2-in. scale models.

If a careful comparison of the diagrams in this figure be made, the reader will find that slight variations in profile (irrespective of depth and thickness) are indicated. This is more noticeable in the 1½ and 2-in. scale examples, the latter having less rounding of the edge of the flange, and a smaller fillet or radius in the angle of flange and tread. Where the railway is not laid very closely to gauge, the section of the tyre had far better be more angular; however, supposing the best quality of permanent way is employed, and the railway is not out-of-doors and does not have to withstand the rigours of an English climate, then a much greater amount of rounding may be given to the profile of the flange with the advantage of a considerably reduced train resistance. The treads of the wheels should, in all cases, be very slightly coned, the angle varying in small models from 1 in 30 to 1 in 20 in larger engines.

Specific examples of wheel designs are given in fig. 95, page 91, the various sizes and types being drawn to a common scale, viz., ¼ in. to a foot. The diameters of carrying and tender wheels are generally from 3 ft. 6 in. to 4 ft. 6 in.; bogie wheels 3 ft. to 4 ft.; driving wheels of coupled express engines 6 ft. 6 in. to 7 ft., with two notable exceptions of 7 ft. 3 in. (L.Y.R.) and 7 ft. 7 in. (N.E.R.). Single engines have driving wheels from 7 ft. to 8 ft.; the L.B. & S.C.R. singles having 6 ft. 6 in. drivers, and the 'Cornwall' on the L. & N.W.R. 8 ft. 6 in. Express goods engines have almost universally 4 ft. 6 in. to 5 ft. wheels, and shunting tank locomotives 4 ft. or 4 ft. 6 in. drivers. Passenger tanks are generally provided with driving wheels varying from 4 ft. 6 in. to

5 ft. 9 in. in diameter, the L.T.S.R. engines being the exception with 6 ft. 6 in. coupled wheels.

The practice nowadays in the case of inside-cylinder coupled engines is to reduce the throw of the coupling rod crank pins to a dimension somewhat less than the throw of the inside cranks. This procedure has been adopted in the $\frac{3}{8}$-in. scale model illustrated by Plate III., the outside crank pins being $\frac{9}{16}$ in. out of centre, and the inside cranks $\frac{5}{8}$-in. throw. In outside cylinder engines they must be the same.[1] The bosses for the wheels in coupled engines with outside frames and all inside-cylinder single locos being circular, the balance weights may therefore be in any position on the pattern, the wheels being set in their proper places during the operation of fixing them on the axles. Fig. 95, page 91, shows the driving wheel balance weights in the correct position for inside-cylinder engines having the right hand crank leading, the coupling rod crank pins being diametrically opposite to the inside cranks. The dotted lines show the position and approximate magnitude of the weights for coupled wheels of both inside and outside-cylindered single and double framed engines. There is no necessity to have the surface of the spokes of carrying or bogie wheels coned other than for the purpose of appearance, and the inside face of the bosses of these wheels may also be made flush with the surface of the tyre.

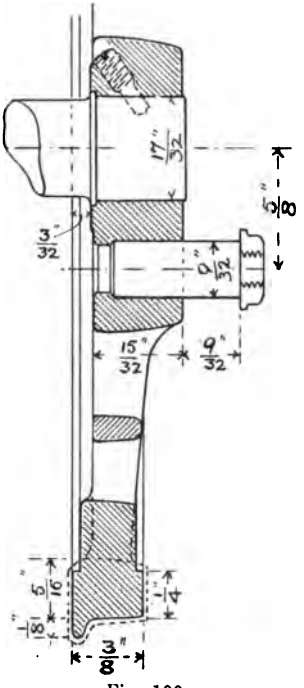


Fig. 100.

There is no operation in which model practice varies so much as in the fixing of the wheels upon the axle, and it is hard to recommend one method or the other in all cases. One of the best ways is to fix the wheels by boring the boss for a driving fit on the axle, which should be turned with a shoulder or have a collar as illustrated in fig. 100, the wheels being secured by a grub screw

[1] There are exceptions, notably the G.N.R. 'Atlantic' locomotives.

driven through the boss from the back. The writer has found, however, that this method of securing the wheel, whilst it facilitates the removal, is sometimes troublesome, and may be substituted in larger models for the fixing shown in fig. 101, where the grub screw is driven parallel to the axle, half into the axle and half into the boss. However, as this makes a more or less permanent fixing, a grub screw arranged in the first-mentioned manner may be used as well, and should suffice for the securing of the wheel during the construction of the model.

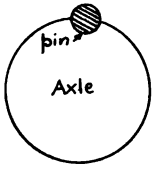


Fig. 101.

If machine tools of the necessary accuracy are to hand, and if the maker is equal to the task, the wheels may be completely finished before fitting to the axles, the turning being accomplished on a mandrel or in the self-centring chuck. Many readers will, however, prefer the surer way of fitting the wheels truly on the axle by turning the whole job between the centres of the lathe, the wheels being first rough turned and bored.

With coupled wheels great pains should be taken to get the crank pins on each pair of the wheels involved exactly at right angles with one another, and also to see that the outside crank pins of an inside-cylindered engine are directly opposite to the main crank pins, although this point is not of so great importance to the fitting of the rods as the first, the position of the outside crank pins in relation to the inside pins affecting the balancing of the motion only.

Some model mechanics think that the driving wheels should be screwed on to a shoulder or collar, as by this means the wheels may be taken off repeatedly. It must be pointed out that difficulties arise where coupling rods are present. It is almost impossible to ensure that just at the point where the wheels screw tightly home against the shoulder or collar on the axle, the crank pins will be at the proper angle with each other and to the main crank of an inside-cylindered engine. Therefore, whilst this method of securing the wheels to the axles has some good points, it cannot be unreservedly recommended. However, for single driving wheels and carrying wheels, and throughout in small locomotives, it forms one of the most suitable fixings. The wheels should be rough turned on the back, bored and tapped at the one setting, and for

finishing, the wheels on the axles should be placed between the centres of the lathe.

When considering the fixing of the wheels on the axle the type of axleboxes to be used should not be forgotten, and if solid boxes with a plain hole are adopted the likelihood of future renewal should govern the design. For such axleboxes one wheel may be permanently fixed to the axle and the other made quite secure, but at the same time readily removable, as shown in fig. 100.

Crank Pins.

Several methods of attaching the crank pins to the wheels suggest themselves, but in all cases the greatest care should be taken,

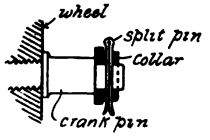


Fig. 102.

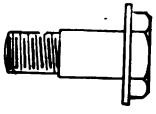


Fig. 103.

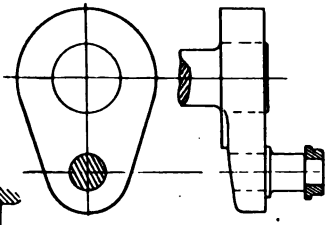


Fig. 104.—Outside Cranks.

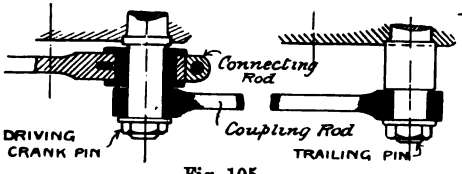


Fig. 105.

CRANK PINS.

especially where the crank pins are to receive coupling rods, to see that the throw and centre line is accurately marked and drilled, and also that the pin is truly vertical to the face of the wheel. Jigs should be used to drill and tap the holes for the pins, which may be fitted as shown in fig. 100, the pins being driven into the wheel and riveted over at the back, or may be screwed into the wheel and riveted over as before (see fig. 102).

The collar which prevents the coupling rod or connecting rod from coming off the pin, may be of the same piece as the pin, as shown in fig. 103, the drawback to this construction being that when it is necessary to remove the rods the pin must be withdrawn. This method also has the disadvantage that the

screwed part must be a very good fit in the wheel, otherwise the pin will be constantly slacking back and falling out, but all the same it will be found quite suitable for small models up to $\frac{5}{8}$-in. scales.

Separate collars fitted to a reduced end of the pin may be employed for large engines, and the best practice is to fit a plain collar, securing it with a split or taper pin (see fig. 102).

A screwed collar may be employed, but in addition to the screwing a pin seems necessary.

If an ordinary cheese-headed screw is used as a crank pin the slot in the head should be filed out when the model is absolutely finished.

In all large models the crank pins should be turned with a collar next to the boss of the wheel, so that the coupling or connecting rods do not touch the wheel on their inner faces. The crank pins for the coupled wheels of outside-cylindered locomotives in which the connecting rods are inside, nearest to the wheel, must be extended to an amount equal to approximately the width of the connecting rod brasses, as shown in fig. 105.

Outside-framed engines having coupled wheels require outside cranks into which the crank pins are fixed, as shown in fig. 104. The crank should be 'backed off' towards the pin, and may be secured to the axle in the best manner possible by a pin passing through the axle and the crank, both of which should fit each other perfectly.

Bearing Springs.

Generally speaking, for essentially working models, spiral springs should in all cases be employed. They are easy to adjust, simple to make; tempered steel springs down to $\frac{1}{8}$-in. outside diameter are commercial articles, and endless time will be saved where they are used. Model plate springs are difficult to make, and besides being much too stiff if made to scale, have little range of action.

Slipping is very often caused by the use of laminated springs on carrying wheels only, more especially in the case of bogie single driving express locomotives. The extent of the deflection of laminated springs being so limited when the road falls hollow at

the centre of the wheel-base, practically the whole of the weight of the engine is thrown on the carrying wheels, which do not respond and equalise the loads on all the wheels.

To give laminated springs more 'life' than is obtainable if they are made to scale, and at the same time to allow of the over-all dimensions of those of the prototype to be adhered to, the construction indicated on the drawings (fig. 106) for the tender bearing springs for a model $\frac{3}{4}$-in. scale Caledonian Railway locomotive, the spring of the original having some fifteen plates, is

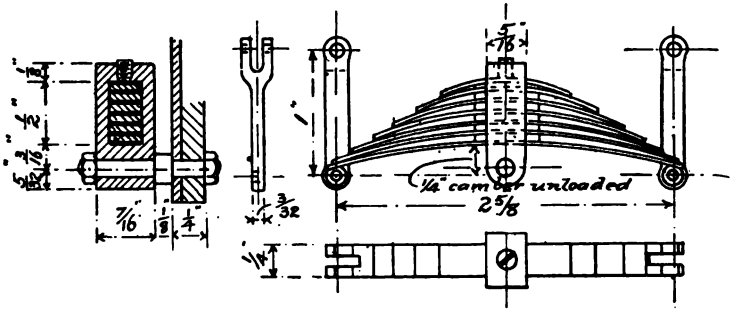


Fig. 106.—Bearing Springs and Hangers for $\frac{3}{4}$-in. Scale Model Caledonian Railway Locomotive Tender.

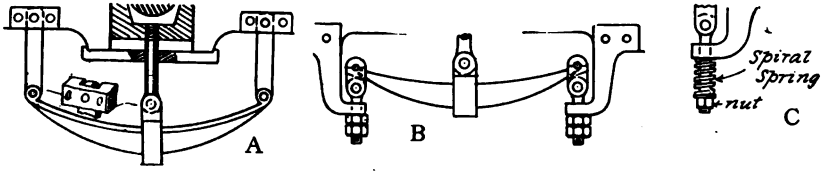


Fig. 107.—Bearing-spring Arrangements.

suggested. The 'back plate'—the longest plate—of the spring should be annealed at the ends, and be either carefully and slowly bent to form the eyes to receive the pins of the hangers; or, which is perhaps a better method, have a piece of tube silver-soldered on to it. The ends of the back plate, and also the two plates above, must, before the spring is re-tempered, be forked to allow the hanger to work freely. The number of plates adopted for the model is seven, cut to the proper length from $\frac{1}{4}$-in. thin clock spring, and to preserve the scale size of the spring, packing pieces of brass plate, about $\frac{1}{2}$ in. $\times \frac{1}{4}$ in. $\times \frac{1}{16}$ in. thick, may be placed

between each plate. The plates should be secured in the buckle by a set-screw driven from the top as shown.

Laminated springs for driving and coupled wheels, where they are underhung, as is usually the case, if fixed as shown at A, fig. 107, cannot very well be adjusted. If the arrangement shown at B is

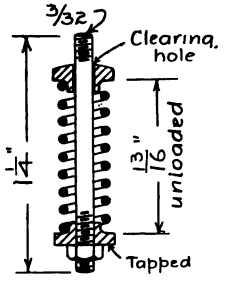


Fig. 109.—Spring Pin for ⅝-in. Scale Locomotive.

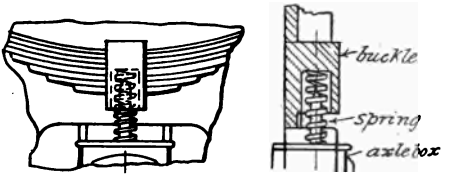


Fig. 108.—Dummy Laminated Springs.

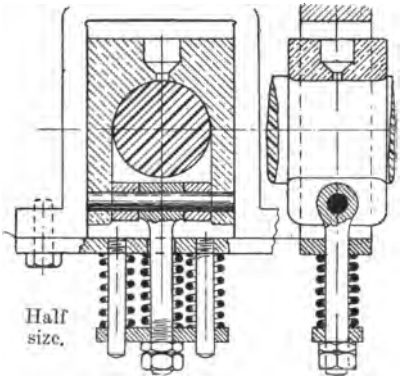


Fig. 109A.—Axlebox and Springs for 1½-in. Scale Locomotive.

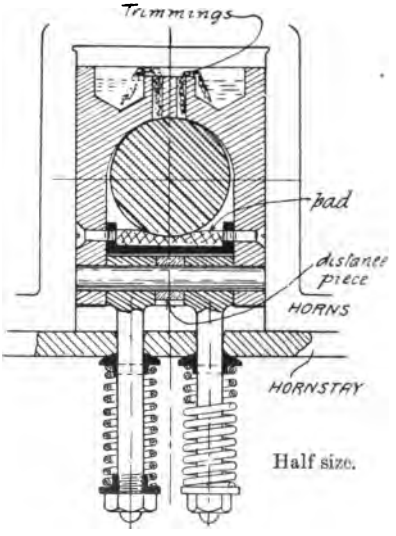


Fig. 110.—Axlebox and Springs for 10½-in. Gauge Locomotive.

adopted, the amount of weight to be borne by each axle can be regulated by the nuts B, and should the springs not exhibit too much 'life,' spiral springs may be placed between the hangers and the nuts as shown at C.

In Plate VIII. the use of compensating beams in connection with laminated springs is illustrated. This construction can be heartily recommended for model work. From the drawings it will be seen

that the frames are extended downwards between the coupled wheels and carry a forked casting into which is pivoted the compensating beam. Holes are drilled vertically in the extremities of the beam to take the spring hangers, which are adjustable by double nuts underneath.

Considerable time may be saved in the construction of a model locomotive, where, say, laminated springs are important features in the exterior design as in outside-frame engines and tenders, by having dummy springs, cast either separately or in one piece with the side frames, and drilling the buckle to take a small spiral spring as shown in fig. 108. The scale appearance of the locomotive is preserved by this method, and the objectionable features of the model laminated spring are entirely eliminated.

Spiral springs for small models may be obtained to just fit over a $\frac{3}{32}$-in. or $\frac{1}{8}$-in. spring pin, but in all better-class work it is advisable to use collars, as shown in fig. 109, to prevent springs departing from the vertical line and becoming broken. Springs are procurable in 9-in. lengths, and after cutting, the ends must be softened and bent so that they will sit squarely on the collars at either end; and as a guide to the finishing-off of the ends of spiral springs, attention is directed to the two ends of a compression spring as usually sold.

Two springs should be used for large models, and instead of the spring pin being simply screwed into the axlebox or keep, the pin should be eyed at the top end and engage a thick pin attached to the axlebox at right angles to the centre line of the axle (see fig. 109 and Plate VIII.). Two methods of arranging multiple springs are shown in figs. 109A and 110.

Straight Axles.

Straight axles for model locomotives are usually turned from bright mild steel rod, and generally they need not be to scale as regards diameter and profile. A good rule to determine the diameter is to multiply the dimension of the scale of the model by $\frac{9}{16}$ in., the result being the diameter of the axle in inches.

For instance, for a 2-in. scale model this equals

$$\frac{9}{16} \times 2 = 1\frac{1}{8} \text{ in.};$$

for a $\frac{3}{4}$-in. scale model,

$$\frac{9}{16} \times S = \frac{9}{16} \times \frac{3}{4} = \frac{27}{64} = \text{say } \frac{7}{16} \text{ in.}$$

Fig. 111 shows a straight axle for an inch scale model, and fig. 112 one for a $\frac{3}{4}$-in. scale bogie tender or other carrying wheel, in which

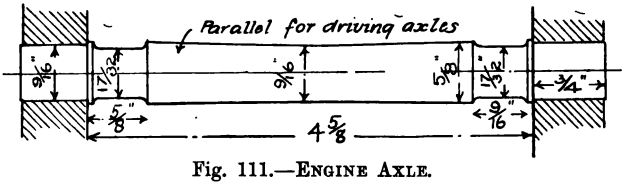


Fig. 111.—ENGINE AXLE.

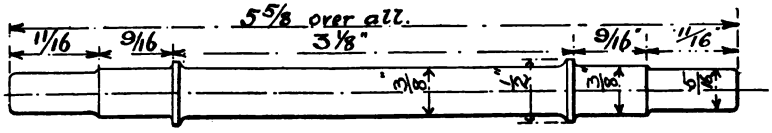


Fig. 112.—TENDER AXLE FOR OUTSIDE BEARINGS.

the axleboxes and frames are placed outside of the wheels. A suitable box for the latter axle is shown in fig. 236, page 184.

CRANKED AXLES.

The manufacture of the cranked axle has no doubt deterred many from building an inside-cylinder model locomotive, and it is perhaps for this reason, and the fact that the difficulties of fitting and erecting are increased, outside-cylindered engines are most favoured by model makers. However, "needs must" sometimes, and the many ways in which a crank axle can be made require consideration.

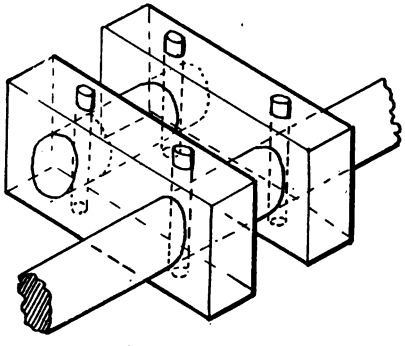


Fig. 113.—SKETCH OF CRANK DURING CONSTRUCTION.

The simplest method of construction is exemplified by fig. 113, and should prove quite suitable for $\frac{1}{2}$-in. or $\frac{9}{16}$-in. scale model, the following

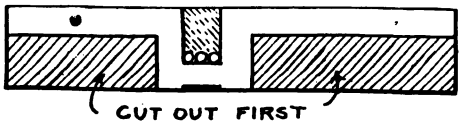


Fig. 114.—Making a Single-throw Crank Axle from a Flat Bar.

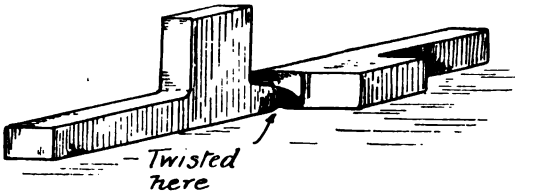


Fig. 116.—A Double-throw Crank Axle after Twisting.

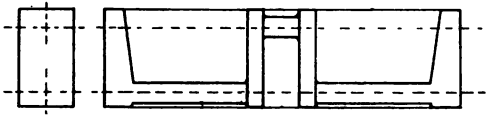


Fig. 115.—Making an Axle as in Fig. 114, but with Throw Plate cut out of the solid.

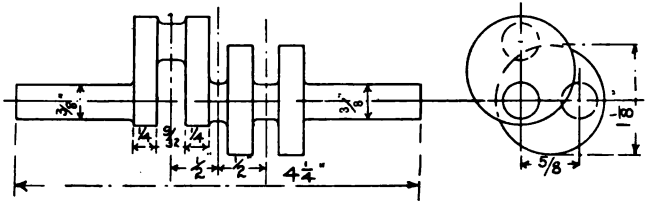


Fig. 117.—A Crank Axle for a $\frac{1}{8}$-in. Scale Model.

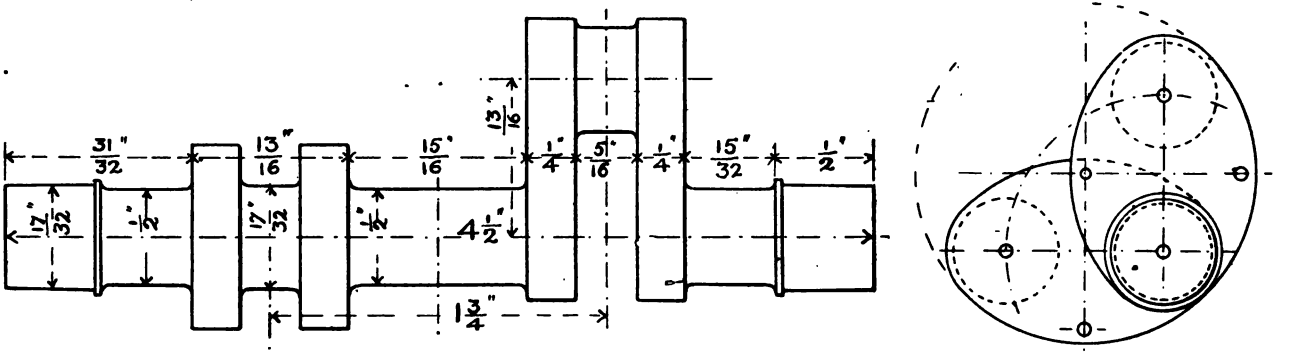


Fig. 118.—Crank Axle for a $\frac{3}{4}$-in. Scale Caledonian Railway Locomotive to be cut from the Round Bar.

description being arranged for the crank axle of the single cylinder design illustrated on page 251.

The axle should be cut from a rod of Stubbs' steel and be centred as accurately as possible, so that no turning will be required except at the wheel-seat. Two pieces of mild steel $\frac{5}{16} \times \frac{3}{16} \times \frac{7}{16}$ in., to form the webs, should be filed square, and in each two holes should be drilled, one at either end $\frac{1}{2}$ in. apart, to take, rather tightly, the axle and the crank pin; the latter can be cut off a piece of the same rod as the axle. The crank pin and webs can be placed in the correct position, and the whole sweated with tinman's solder.

After the preliminary sweating together the pins should be fitted as shown in the sketch, when the whole job may be again subjected to the heat of the flame. These pins should be a good fit, the holes being carefully broached. To complete the work the pieces of the axle remaining between the webs may be sawn out and webs filed up to the best of the maker's ability.

Of course if a gas blowpipe of sufficient power or a paraffin blow lamp is available, then the job may be brazed right away, the pins being fitted before the work is placed in the fire.

Another method of building such a single-throw cranked axle is shown in fig 114, and very good results can be obtained with a comparatively small amount of labour. A flat bar of mild steel $\frac{5}{16} \times \frac{7}{16}$ in. in section (for the engine under consideration) should be procured, and with a hacksaw all superfluous metal at each side of the webs should be removed; the axle can then be turned to its proper diameter. The piece of metal between the webs being cut away, the crank pin may be turned by means of throw plates screwed or otherwise fixed on to the ends of the axle.

A double-throw cranked axle can be made in a similar manner to the above, but in this instance it will be necessary to heat the axle at the centre and to twist the cranks at right angles after cutting out the superfluous metal at the axle as already described. The appearance of the axle subsequent to heating and twisting is illustrated by fig. 116.

In a built up and brazed cranked axle for engines of larger dimensions (*i.e.* $\frac{3}{4}$ in. and 1 in. scales) eccentric sheaves, where they are between the webs, may be placed on the middle piece before fitting the parts together for brazing. All joints to be brazed should

be grooved to allow of the spelter to flow throughout the joint, and should be pinned to prevent movement. Brazed crank shafts for engines larger than 1-in. scale should not be employed, as they cannot be relied upon.

A method suggested for the 'Dunalastair' ¾-in. scale model locomotive (Plate VII.), is indicated in fig. 118, and consists of cutting the axle from a solid bar of mild steel. It entails a deal of heavy work, but one advantage of the method is that no forging

Fig. 119.—A Crank Axle with Eccentrics turned from one Piece of Metal.

is required. Carefully marking out is of course essential to success, and if eccentrics are also included, as in the example kindly lent to me by Mr. James Mackenzie and illustrated herewith (fig. 119), care must be taken to use the right centres for each of the eccentrics, remembering that the two forward ones are on the outside nearest the crank webs or both on the inside, as the case may be. The photograph shows the various centres in the remaining parts of the original bar of steel, which discs are cut off after the whole of the other work is finished.

The work in the machining of a model cranked axle from one piece of metal may be considerably lightened by the use of a pattern in wood, castings being obtained in malleable iron (sometimes called "cast mild steel"); and although if only one engine is to be built it will not be worth while to adopt this procedure,

some model manufacturers have already availed themselves of this method, and castings in several sizes may be procured. A photograph of a typical casting from a design by the author (fig. 117), on which the centring lugs (or throw plates) are cast on the axle,

Fig. 120.—A Cast Crank Axle for $\frac{5}{8}$ or $\frac{3}{4}$-in. Scale Locomotive.

is shown on fig. 120, the finished axle being illustrated in the photograph on page 167. The throw plates are cut off after the crank pins and webs have been finished.

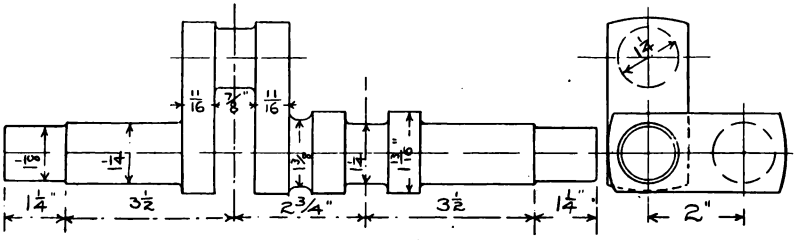


Fig. 121.—Crank Axle for 10¼-in. Gauge Locomotive.

Cranked axles for 1¼, 1½ and 2-in. scale engines should always be *forgings*, or cut out of the flat plate as shown in fig. 116, the webs being twisted after cutting out. A crank axle suitable for a 2-in. scale model is shown in fig. 121. Webs should be ⅓ S

in thickness (S equalling the dimensions of the scale of the model), *i.e.* for 2-in. scale $\frac{5}{8}$ in. or $\frac{11}{16}$ in.; for $\frac{3}{4}$-in. scale $\frac{1}{4}$ in., and 1-in. scale $\frac{11}{32}$ in. thick. If square webs are used the face width should be $1\frac{1}{4}$ times the diameter of the axle.

The crank pin journals should be the same diameter as the bearing journals, and the length of pin (width of journal) should be $\frac{1}{2}$ or $\frac{7}{8}$ S, *i.e.* $\frac{1}{2}$ in. or $\frac{7}{16}$ in. for inch scale, $\frac{1}{4}$-in. for $\frac{1}{2}$-in. scale. The diameter of crank axles at the journals should be $\frac{5}{8}$ S. Crank axles of the built-up variety, the strength of which depends upon the brazing, should not be used for models larger than 1-in. scale, except under special circumstances.

Fig. 122.—A View of the Back Plate of a $\frac{3}{4}$-in. Locomotive Boiler.

CHAPTER VII.

Cylinders and Valves.

Before the builder can even decide on some of the vital points in the design of a proposed model locomotive the cylinder bore must be determined, and to accomplish this the reader is referred back to Chapter III.

British locomotives have as a rule inside cylinders—*i.e.* cylinders placed between the frames—and a cranked axle; and it is obvious that the difficulties of construction are to a large extent increased in a model by this arrangement, especially when it is accompanied by valves between the cylinders.

Whilst some of the model locomotive designs herewith embody this arrangement, those who wish to lessen labour may adopt alternative types with advantage. In this matter, as in others, the question the maker must decide for himself is, shall the efficient working govern the design, or is a scale model the chief object in view?

With working models built to scales of $\frac{5}{8}$ in. and upwards it is possible to place the cylinders together, with the valve chests abreast but *outside* instead of between the cylinders, the whole not exceeding the width of the frames. This system confers two benefits which will be deemed considerable by all who will look into the accompanying figs. 123 to 128, the first being the accessibility of the valves for repair and setting. Secondly, the eccentrics sheaves need no splitting, being on the outside of the cranks. Again, this method produces a very smooth running engine, the centre of motion lying so near to the centre line of the engine.

The design (fig. 123) is arranged for a $\frac{3}{4}$-in. scale model having $\frac{3}{4} \times 1\frac{1}{2}$-in. cylinders, steam ports $\frac{5}{16} \times \frac{3}{32}$ in., and exhaust ports

$\frac{3}{16}$ in. wide, port bar being $\frac{3}{32}$ in. thick. The cylinder covers may be in one piece or separate as shown, the former plan getting rid of the vertical joint at the centre line of cylinders, and the latter ensuring the covers being true and square with the cylinder bore.

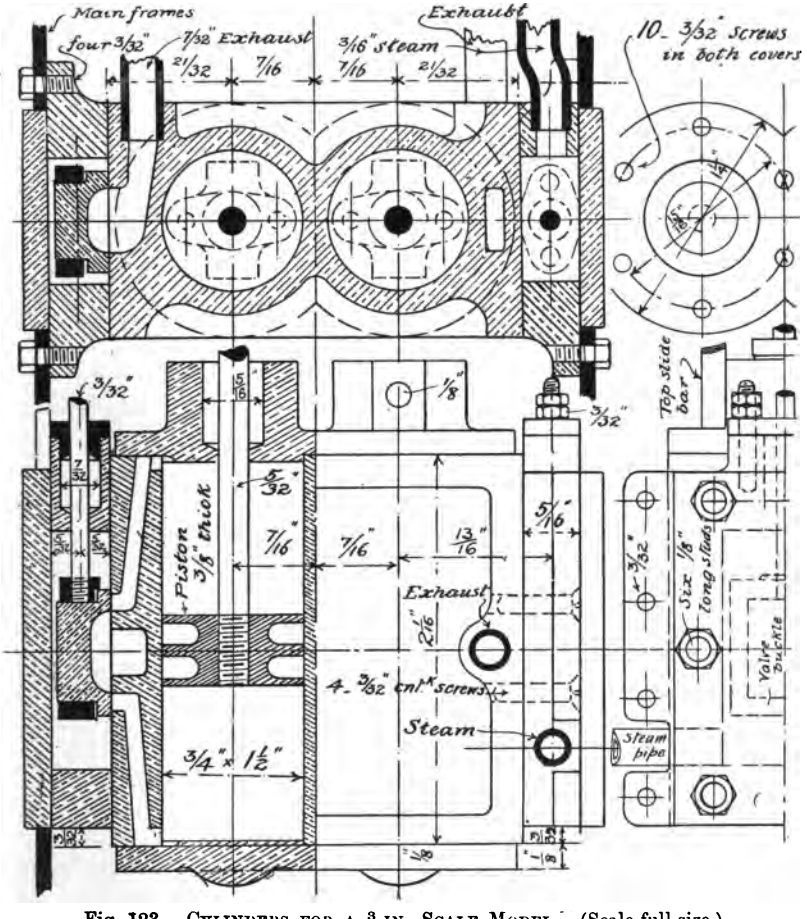


Fig. 123.—Cylinders for a $\frac{3}{4}$-in. Scale Model. (Scale full size.)

Separate covers may be arranged for the back (stuffing box) covers, these being sweated in place as well as screwed, a single square cover being used in the front. The small sketch (fig. 124) explains a method of constructing the exhaust passages, without the use of cored patterns, where vertical height is to be cut down.

The passages can all be made with a drill, the ends being plugged where necessary.

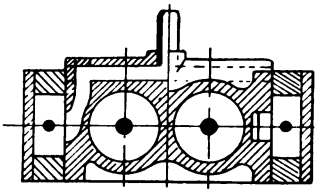


Fig. 124.

Cylinders of this pattern may be fixed to the main frames by being attached to a cross beam (or bogie-pin casting in a bogie engine) as will be necessary if the steam chests are of the pattern shown in fig. 124; or the methods implied by fig. 123 may be employed, another and a larger example of this type of cylinders suitable for a 2-in. scale locomotive being illustrated in fig. 125. It will be seen by the drawings that the latter cylinders and steam chests are in one casting and 2 (or $2\frac{1}{8}$) bore by 4 in. stroke. The flanges for fixing the cylinders are cast on the sides of the steam chest, and are sufficiently deep to allow of a good joint for the cover and plenty of metal for the fixing bolts. The ports (steam $1 \times \frac{1}{4}$ in., exhaust $1 \times \frac{1}{2}$ in.) are of ample proportions, and can be 'cast in.' To facilitate machining, the

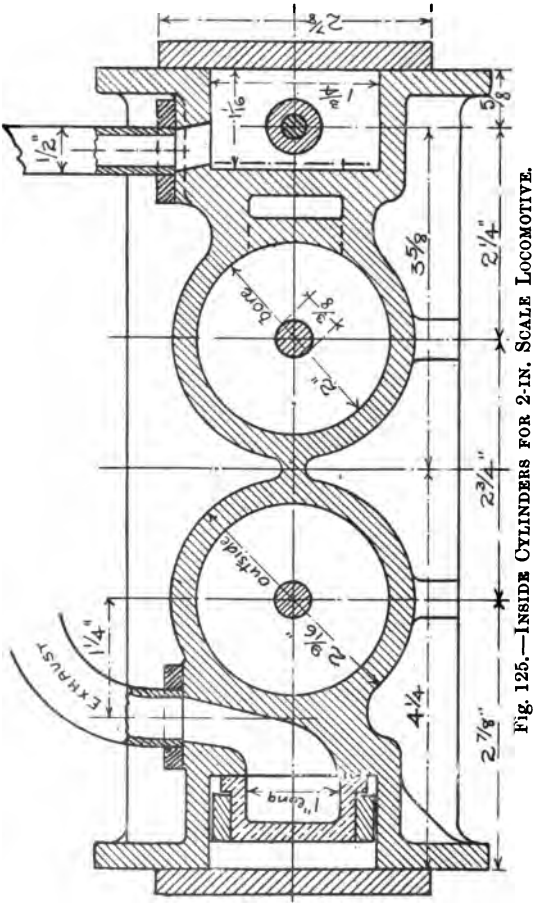


Fig. 125.—Inside Cylinders for 2-in. Scale Locomotive.

cylinders have no projections on the four finished sides, and the hole for the steam pipe shown on the plan view is not provided for in the patterns, being drilled (at an angle, it will be noted) afterwards. The slide valve face of the cylinder is raised, this face being machined with a milling cutter and finished by

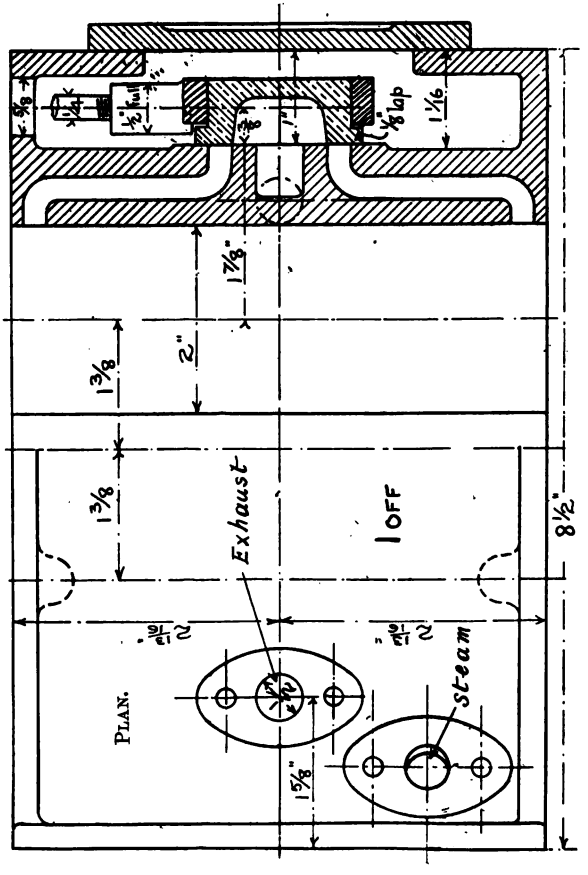
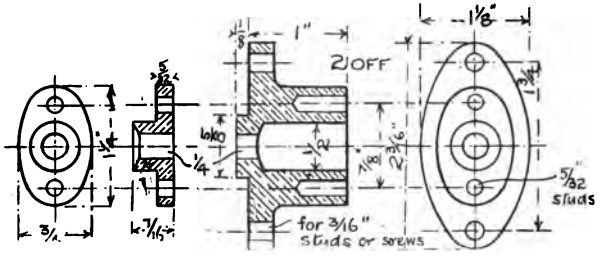


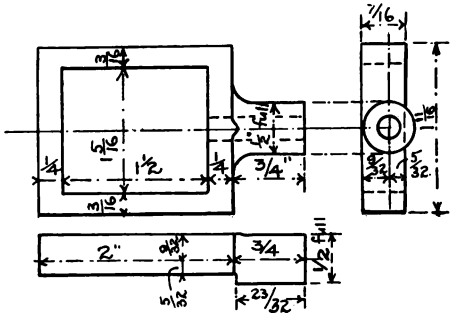
Fig. 126.—PLAN OF 2 × 4 IN. CYLINDERS FOR A 10½ IN. GAUGE 2-IN. SCALE LOCOMOTIVE. (Scale half full size.)

scraping. The valve spindle stuffing box is a separate casting (see fig. 127) and the valve is clasped by a buckle. As the drawings are very complete the writer may leave this design and pass on to another example of model inside cylinders (fig. 129). Here the valve chest may be below or above according as circumstances dictate, the drawings showing the various ways

in which they may be employed. The chief point of interest is the arrangement of the steam and exhaust passages. In the 'valves below' set the exhaust passage is drilled in the casting, the entrance to the horizontal hole being plugged after drilling. A short piece of tube forms the blast pipe, this being the only tubing necessary except the steam pipe, which similarly comes straight down to the cylinder casting without awkward joints or bends. The passage to the steam chest is drilled on the same



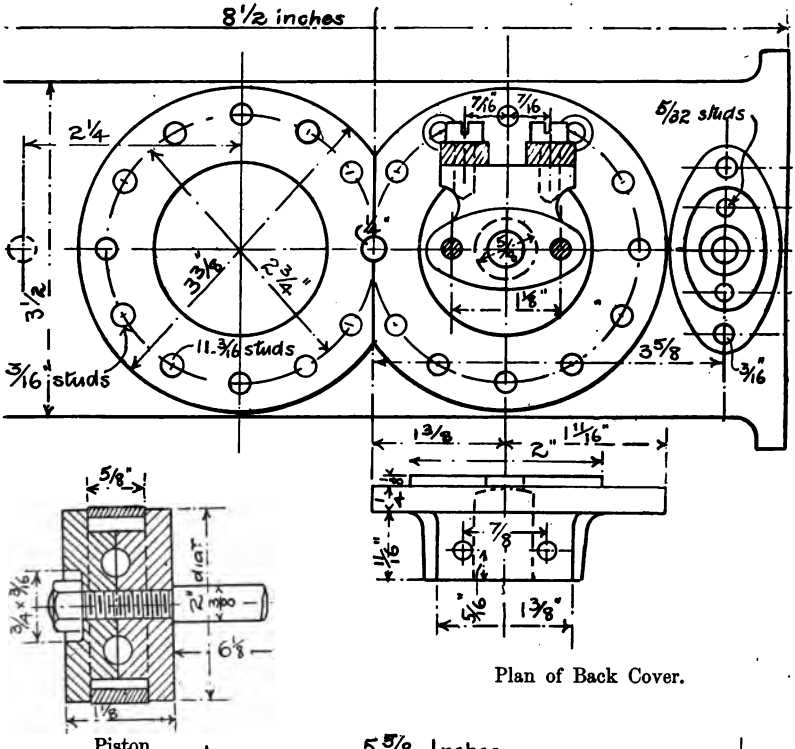
Valve Spindle Gland. Valve Spindle Stuffing Box.



Valve Buckle.

Fig. 127.—Details of 2 × 4 in. Cylinders for 10¼-in. Gauge Locomotive.

centre line as the exhaust but with a slight 'fore and aft' rake, bringing it at the lower end well inside the wall of the steam chest. The cylinders with the valves on top render a slightly different arrangement of piping necessary, but the same general simplicity is maintained. The exhaust pipe, as will be seen in fig. 131, has to pass through the steam chest. To prevent leakage from one to the other, the screwed end of the exhaust pipe is



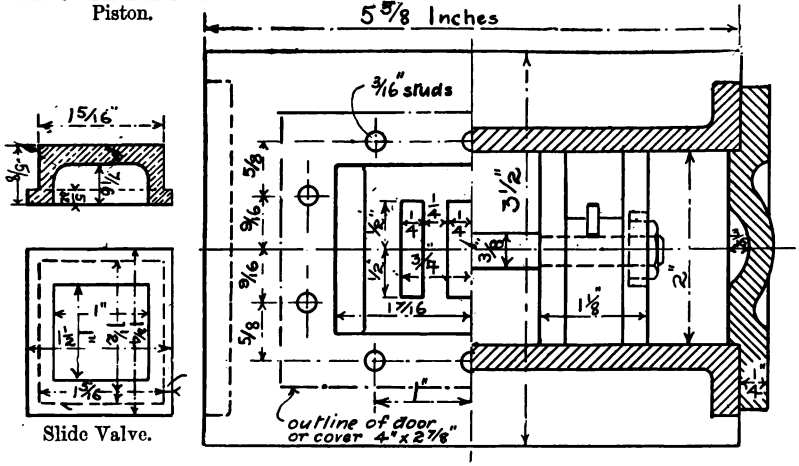


Fig. 128.—Details of 2 × 4-in. Cylinders.

chased taper, so that if smeared with a little red lead and oil it will screw up quite steam-tight. A gland nut screws down on to the cover at the top. This nut has a concave profile on the underside, and with the countersinking of the hole in top of the cover, a turn or two of asbestos string placed into the recess thus formed will complete the joint. The steam pipe may enter the steam chest in whatever position it is found most convenient. Fig. 134 illustrates a larger size of cylinder (for a $\frac{3}{4}$-in. or $\frac{7}{8}$-in. scale engine), the link motion for which is shown on page 163.

The first arrangement of cylinders with the valves below renders valve setting a simple matter; it is only necessary to turn engine upside down and remove the bogie (if any) and take off the valve chest cover. Not a single pipe is disturbed, and the boiler may

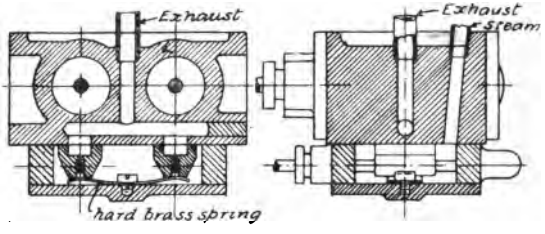


Fig. 129.—CYLINDERS WITH VALVES BELOW. (Scale, half full size.)

remain in its place. A spring should be fitted on the steam chest cover to keep the valves on their faces; this is not required when the valves are above the cylinders. For both designs (figs. 129 and 131) only one set of patterns is necessary.

Turning to the orthodox types of inside cylinders—copies in a more or less degree of actual examples—fig. 135 illustrates the cylinders designed by Mr. Pearce for the $\frac{3}{4}$-in. scale model Caledonian locomotive No. 902 (the so-called 'Dunalastair III.'). The only drawback in this arrangement where a practical working model is desired, is the accurate workmanship required and the inaccessibility of the valves for purposes of setting and other adjustments, to say nothing of the restriction of cylinder diameter and steam passage area.

The following notes on the construction of these cylinders should be of use to the builder, many of the processes being the same whatever design is adopted.

One pattern will do for the two cylinder castings, and the dimensions given below include an allowance for shrinkage and machining. Length, $2\frac{1}{4}$ in.; depth, $1\frac{9}{16}$ in.; valve face, $\frac{11}{16}$ in. from centre of cylinder; side flanges, $\frac{9}{16}$ in. from centre and $\frac{5}{32}$ in. thick; the body of cylinder is $1\frac{1}{16}$ in.; core prints, $\frac{5}{8}$ in. diameter and $\frac{1}{2}$ in. long. A box for the exhaust passage is fixed on the side of valve face on top of the cylinder where shown on plan. The end flanges should be $\frac{3}{16}$ in., and should project beyond the rest of pattern $\frac{1}{16}$ in. for a depth of $\frac{15}{16}$ in., as shown on section of cylinder. The top of side flange is $\frac{1}{8}$ in. higher between the end flanges than

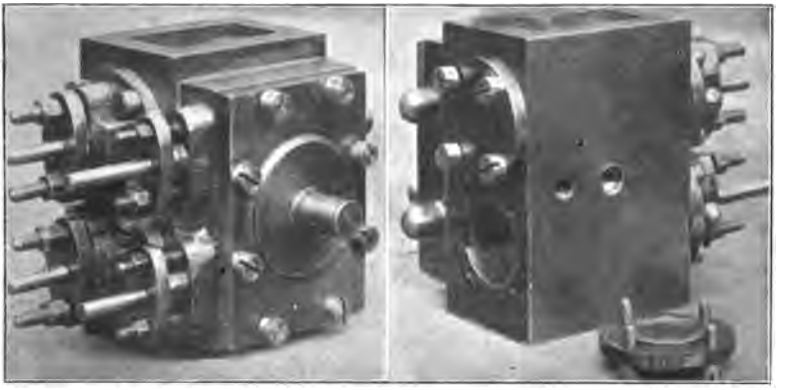


Fig. 130.—A Set of Cylinders with Valves below.

the rest of pattern. This is to bring the line of top bolts above the footplate.

The cylinder cover patterns should be $1\frac{5}{16}$ in. diameter, and $\frac{5}{32}$ in. thick, with a projection of $\frac{3}{32}$ in. on the inside, $\frac{7}{8}$ in. diameter for checking into cylinder, the back cover having the stuffing box and slide-bar lugs cast on.

The steam chest is a plain pattern, the same length and depth as cylinder pattern, $\frac{9}{16}$ in. wide and $\frac{3}{8}$ in. thick all round, having a boss at back for valve spindle stuffing box.

The cylinder castings should be first lined out, the cylinder being plugged at each end with a piece of hard wood and a circle $1\frac{3}{16}$ in. diameter scribed round in correct position of bore. Then place the cylinder on a surface plate and pack it up to get centres at each end true with a scribing block, and the valve face and

side flanges square with plate. Then set out the lines at top and bottom of flanges and round valve face, $\frac{3}{4}$ in. each side of centre. Next turn the cylinder over so that it will rest on the side flanges, and adjust the packing till the centres are again true, and the lines just scribed round are square with the surface plate; then set out and scribe the line of valve chest seating $\frac{5}{8}$ in. from centre of cylinder, and the side flanges $\frac{17}{32}$ in. from centre. A portion of the end flanges project $\frac{1}{16}$ in. for a depth of $\frac{7}{8}$ in. to fit in the opening left in the auxiliary frame. It should be mentioned here that an extra piece about $\frac{3}{4}$ in. by $\frac{1}{8}$ in. must be cut away at end of opening in these frames to clear the back cylinder covers, and a slight groove may have to be filed out to clear heads of the two screws in cylinder cover that come close to the frames.

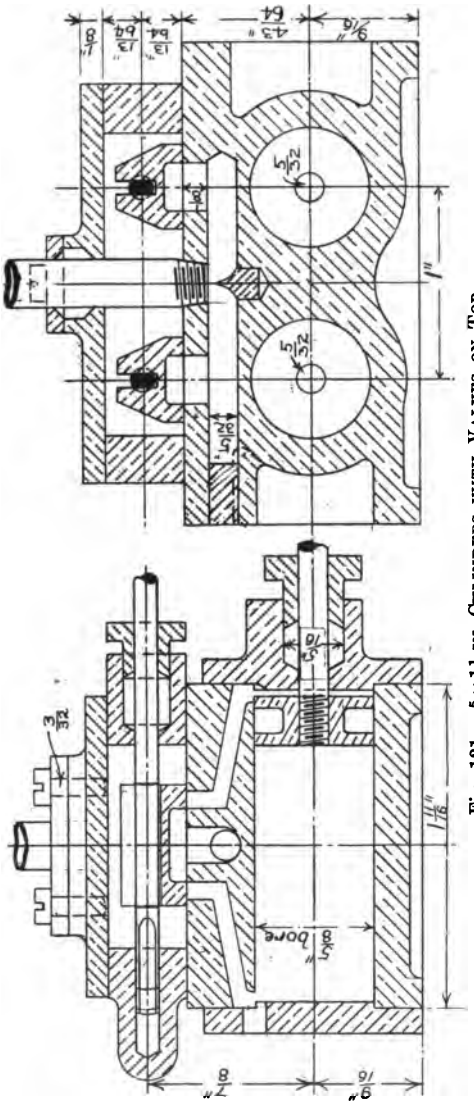


Fig. 131.—$\frac{5}{8} \times 1\frac{1}{4}$-in. Cylinders with Valves on Top.

The cylinder can now be bored out either by chucking on the face plate or by bolting it to an angle plate by the side flanges. The latter method will,

perhaps, hold the casting more securely than if held by the end flange.

In boring with a tool in slide-rest, care should be taken to get a perfectly parallel hole, and with the finishing cut a slow and even feed should be given. The outside flange can be faced off while in position, and the other end when the casting is running true on a mandrel.

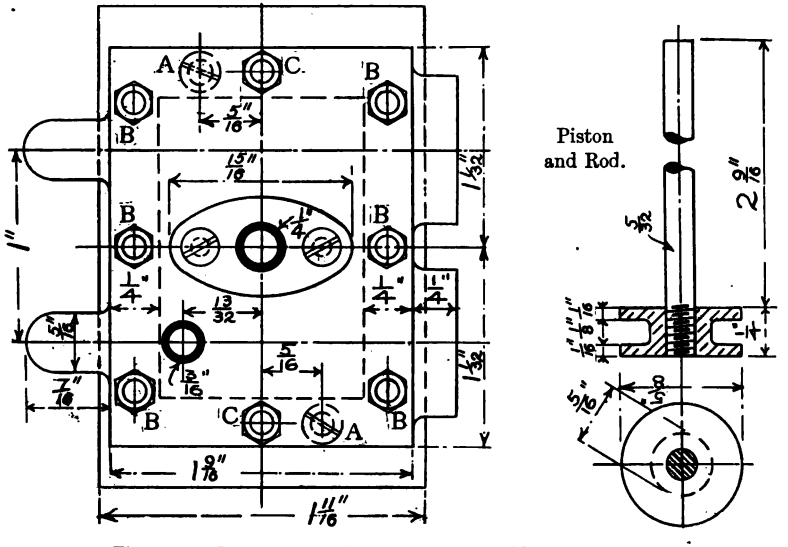


Fig. 132.—Details of Cylinders with Valves on Top.

A, countersunk screws to fix steam chest. B, long studs from cylinder. C, short studs to fix steam chest cover only.

The cylinders may, if preferred, be bored out by fixing to the lathe saddle, and using a boring bar and cutter.

The valve face stands out $\frac{1}{32}$ in. from the steam chest seating, and should be finished perfectly flat and square. The ports should next be accurately set out, the holes being drilled close together just under $\frac{3}{32}$ in. diameter, and finished off to line by filing or chipping with a small chisel to a depth of $\frac{5}{32}$ in. The exhaust port is $\frac{3}{16}$ in. wide; the hole at top should be first drilled $\frac{1}{4}$ in. diameter and $\frac{3}{8}$ in. deep, and from side nearest valve face an $\frac{1}{8}$-in. hole is drilled in a slanting direction to come out at bottom of exhaust port, which can be milled or filed out to a width of $\frac{3}{16}$ in.,

the $\frac{1}{8}$-in. hole being enlarged sideways to the same width as the port.

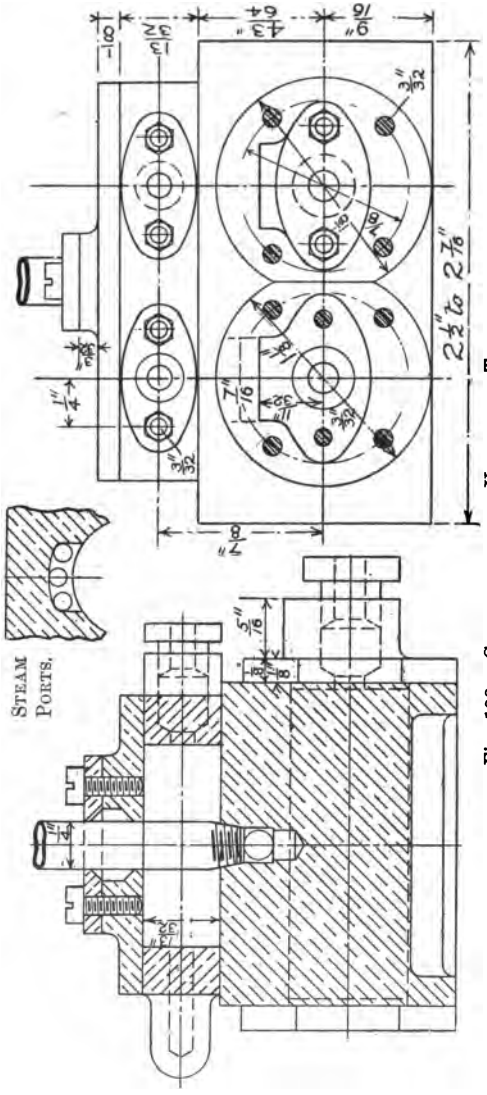


Fig. 133.—Cylinders with Valves on Top.

The steam passages can now be drilled out from the flange ends and cut into cylinder $\frac{1}{16}$ in. from face of flange; the holes coming through to the face can be filled up with a piece of $\frac{1}{16}$ in. brass soldered in.

The back cylinder covers can be held in a self-centring chuck for turning the inside face. They are checked into cylinders nearly $\frac{3}{32}$ in. The hole for the piston rod should be started centrally with a hand tool or a square centre for a depth of about $\frac{1}{16}$ in. to ensure the drill running true. Then fix the turned face of cover in a boxwood chuck turned up to receive it, and enlarge the mouth of the hole to $\frac{5}{16}$ in. diameter and $\frac{5}{16}$ in. deep to form the stuffing box. The slide-bar lugs which project from side of stuffing box should now be filed up parallel with the hole last bored; a short piece of $\frac{5}{16}$-in. round brass could be put in as a guide in filing. Holes should

then be drilled through the lugs for $\frac{3}{32}$-in. bolts or tapped for screws.

The front cylinder covers have a recess inside for the nut at the end of the piston rod, the outside being turned to the section shown.

The box forming the valve or steam chest should be filed or planed up to a width of $\frac{1}{2}$ in., the depth being $1\frac{1}{2}$ in. and length $2\frac{1}{8}$ in., the thickness of metal being $\frac{5}{16}$ in. all round. It should be fixed to an angle plate for drilling the holes for valve spindles; these are $\frac{7}{32}$ in. centres, $\frac{3}{32}$ in. diameter, and counter-drilled to $\frac{5}{32}$ in. full for stuffing-box gland. These holes should be set out and drilled as accurately as possible. This will not be a very difficult matter if the casting is filed up exactly square and fixed to the angle plate in correct position for drilling one of the holes. A strip of $\frac{1}{8}$-in. brass could be bolted on angle plate close up to the sides of casting, and after drilling one hole, the casting can be turned over for drilling the other hole instead of shifting angle plate. This will ensure the holes being the same distance from sides of casting. Drill the hole for steam pipe in the position shown on top, and the holes for screws at each side about $\frac{1}{4}$ in. deep for $\frac{1}{8}$-in. screws for securing the flange of steam pipe. Drill a hole in centre of front end and tap for a $\frac{1}{4}$-in. screw, which can be removed when setting slide valves. The cylinders and steam chest can be bolted together with four $\frac{1}{8}$-in. bolts with nuts at each end as shown in drawing; or the holes in steam chest may be drilled and tapped for $\frac{1}{8}$-in. screws, with clearing holes in the flange. Four holes for $\frac{3}{32}$-in. screws are to be drilled in each of the cylinder side flanges to correspond with the position of holes in frames. Two extra holes should be drilled in each flange for $\frac{1}{8}$-in. screws for fixing cylinders to the auxiliary frames, the heads of screws being countersunk in the frames and filed off flush.

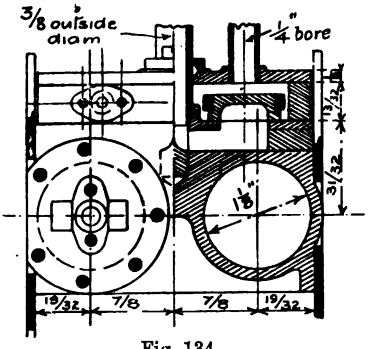


Fig. 134.

The cylinder covers are fixed to cylinders with six $\frac{3}{32}$-in.

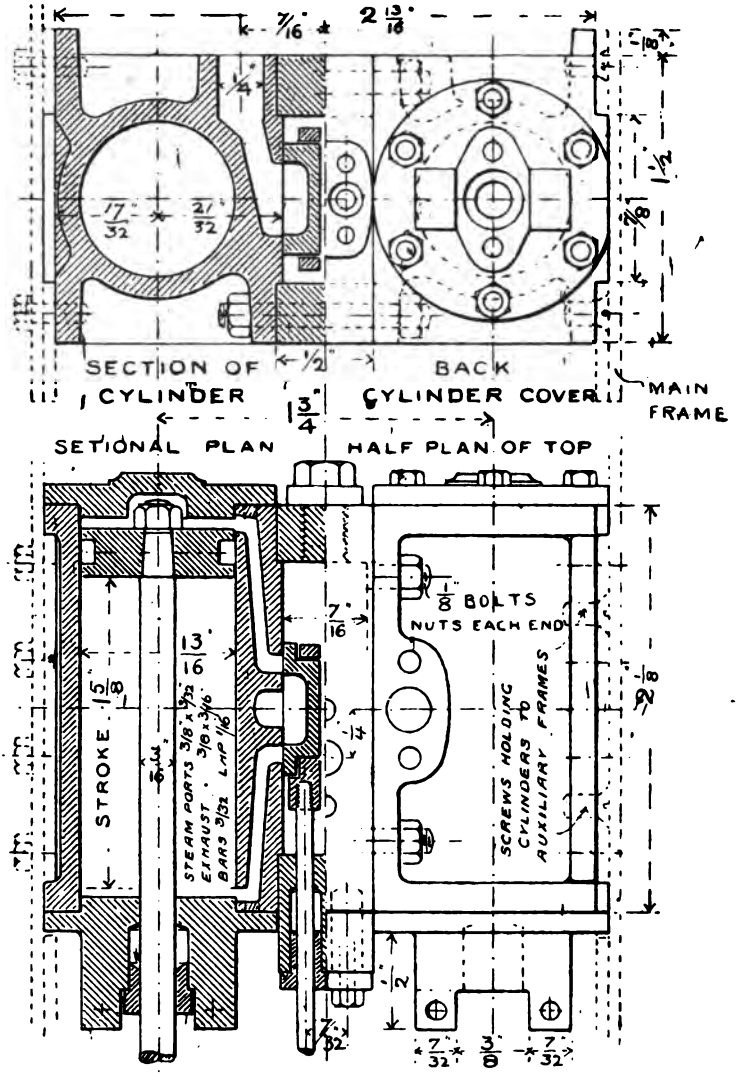


Fig. 135.—Cylinders for a ¾-in. Scale Model Caledonian Railway Locomotive.

screws in the position shown. In marking off the holes for back cylinder cover put a straight-edge across the two sets of slide-bar lugs, so that they will be level when the covers are fixed.

The slide valve is $\frac{11}{16}$ in. by $\frac{9}{16}$ in., the exhaust cavity being $\frac{3}{8}$ in. square and $\frac{1}{8}$ in. deep, finished sizes. The buckle (shown by fig. 136) is filed out to $\frac{9}{16}$ in. by $\frac{1}{2}$ in., to fit back of slide valve easily, and has a boss cast on, which is drilled and tapped to receive the valve spindle.

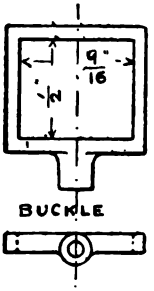


Fig. 136.

A further point of interest in the cylinders for the 'Dunalastair' model is the fixing to an auxiliary frame, shown in fig. 51, page 70, this method of attachment facilitating the packing of the glands.

Although inside-cylinder locomotives are, as far as British practice is concerned, in the majority, a large number of outside-cylinder engines have lately appeared, and it would hardly do not to consider models of these; indeed, it is the general practice of model makers to choose the outside-cylinder type in preference to the other, as by this means a great deal of careful time-taking work is saved.

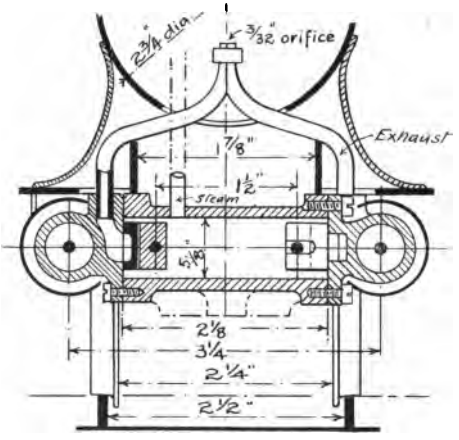


Fig. 137.—Outside Cylinders for ½-in. Scale Model.

Early troubles, more especially in valve setting, resulted in the design shown in fig. 138, which is drawn full size for a 2½-in. gauge (usual standard for ½-in. scale loco.). The method of valve setting, which, by the way, is always best done by sight, is to remove one cylinder and look through the 'connected' steam chest at the valve on the other side. When this valve has been placed in such a position that the opening of the valve is equal on each side and occurs at the right time, the cylinder may be replaced, and the one

which has just previously had its valve adjusted may be removed, taking out the valve also, and making note of the way it stands on

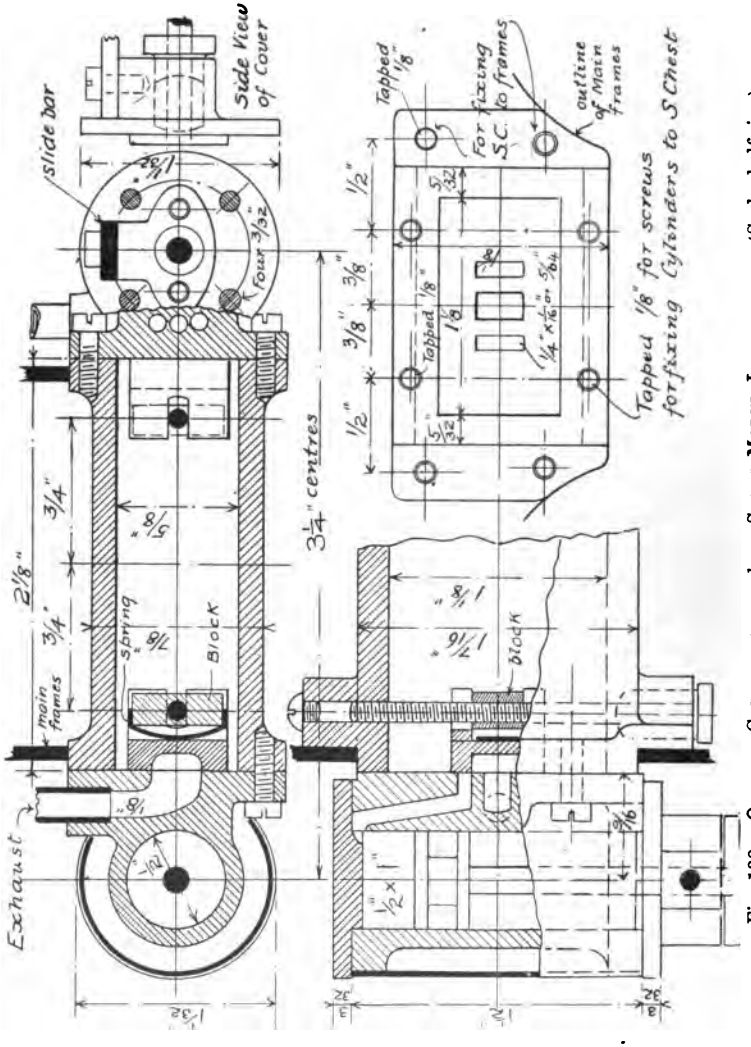


Fig. 138.—Outside Cylinders for ½-in. Scale Model Locomotive. (Scale, half size.)

the spindle. The other side may then be correctly set, and the cylinder last taken down replaced. Of course accuracy depends on the true fitting of the fixing screw clearance holes in the

flanges of the cylinder casting; and care should be taken to see that these are not unnecessarily large.

For some designs, notably the M.R. compound No. 2631, N.E.R. outside-cylinder engines, and the 'Atlantic' type G.N.R. locomotives, a saddle (as fig. 137) cannot be employed to hide the exhaust pipe, and therefore the arrangement given in figs. 139 and 140 is suggested. The placing of the horizontal connecting passage in the body of the steam chest very much simplifies the piping arrangements, and also allows of the shortest possible piece of tubing for the blast pipe.[1] A further improvement embodied in this design is in the method of facing the cylinders at the steam chest joint. This may be done between the centres of the lathe, as the projecting spigot is circular.

It may be urged that the exhaust passages should not come in

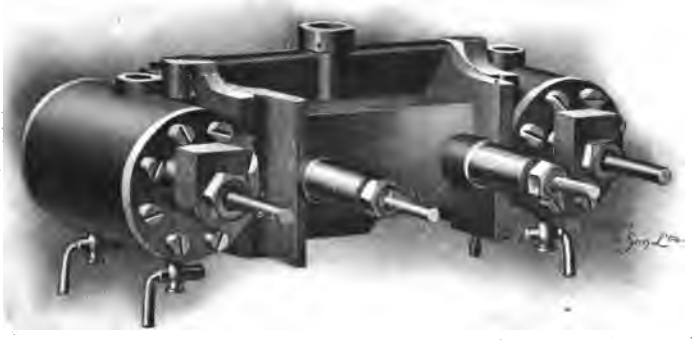


Fig. 139.—Finished $\frac{5}{8} \times 1\frac{1}{4}$-in. Outside Cylinders.

contact with vessels holding live steam. This precaution is very necessary in large work, but is hardly tenable when dealing with such diminutive engines as model locomotives. The varying temperature of the live and the exhaust steam is very small, and considering the mass of metal in the cylinders, there is not likely to be much variation in the temperature of the different parts of the cylinders and steam chest whilst the engine is running.

In larger models it is advisable to have other means of removing

[1] The writer has noticed that model engineers are apt to confuse the blast pipe with the blower. It is not strictly correct to call the blower the 'blast.'

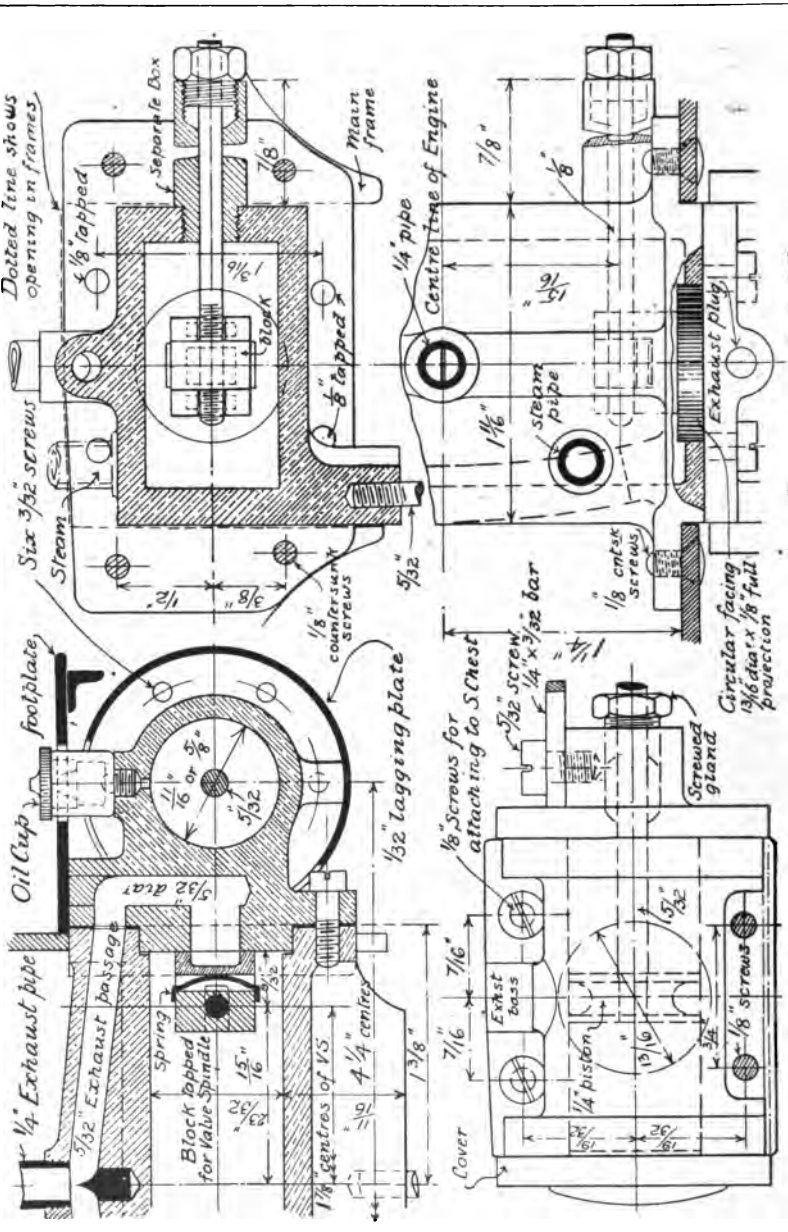


Fig. 140.—Outside Cylinders for a Model 4-in. Scale Locomotive. (Scale, full size.)

and sighting the valves, and with this object a door on the connected steam chest on the underside is a decided advantage. With an engine thus provided the writer has been able to remove the valves, to decrease the lap, in five minutes, by releasing the valve spindle from its crosshead and unscrewing it from the buckle or block after having removed the steam chest door. (See Plates IV., V. and IX. and fig. 69.)

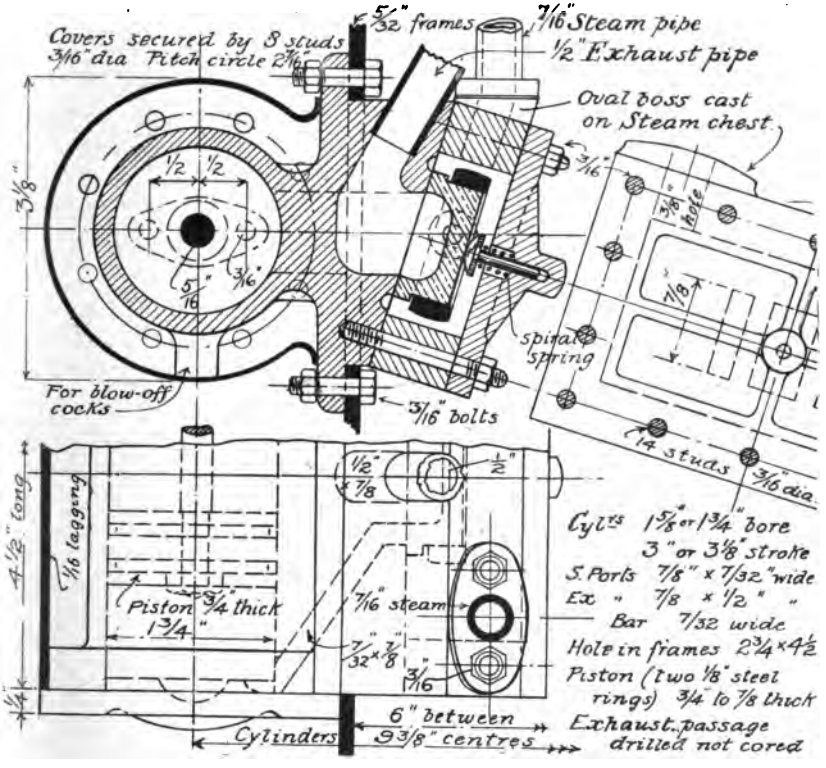


Fig. 141.—Outside Cylinders with separate Steam Chests.

Outside cylinders to 1-in. scale, copying closely those of the original engine, are shown in Plate VIII. (L.T.S.R. design). Here the cylinder and steam chest are cast in one piece. A more difficult pattern is necessary, and altogether the design is not suitable for a model of less than 1-in. scale. The ports may be cast in, but the writer does not think this course advisable in

ports less than $\frac{5}{32}$ in. in width for gun-metal and $\frac{3}{16}$ in. for iron cylinders.

To render the casing outside the frames for the covering the exhaust pipe in the L.T.S.R. design (see Plate IX.) unnecessary, cylinders arranged after the manner of fig. 141 may be adopted.

This pattern is employed in some of the G.N.R. 8-ft. singles. The drawing which illustrates cylinders suitable for 1½-in. scale locomotive is exactly half full size. The steam chests are placed at an angle to allow the valve face to lie closely to the cylinder, and are quite separate from one another, being served by two steam pipes.

Cylinder Details.

Passing on to cylinder details, such as pistons, valves, glands, etc., with regard to the former, for small locomotives having gun-metal cylinders of diameters up to, say, one inch, the ordinary methods of packing a grooved piston cannot very well be improved upon—that is, if the piston is made sufficiently wide. The groove also should be as deep as possible, and can be packed with asbestos yarn, darning cotton, or lamp wick, laid flat or bent up in the shape of an inverted U, the extremities in either case being sewn together.

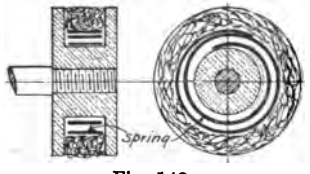


Fig. 142.

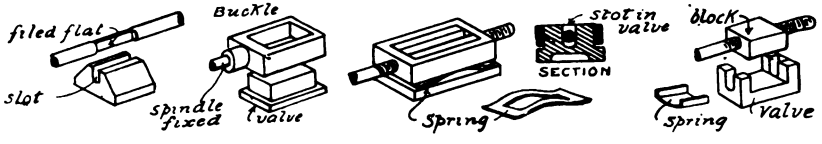


Fig. 143.—Fixing Slide Valves to their Spindles.

A suggestion for packing small pistons, which would appear to offer good chances of success, is shown in fig. 142, and consists of winding a piece of clock spring in the groove of the piston, afterwards overlaying flat lamp wick or other fibrous packing.

Piston rings are said to be unsuitable for gun-metal cylinders.

There are several methods of affixing the slide valves to the valve spindles, and a variety are indicated in the foregoing cylinder designs and accompanying sketches. The different methods of

fitting springs behind the valves to keep them up to the port faces—a course *strongly* advised in positions where the valves are likely to fall off—are to be seen applied in Plate IX. and figs. 129, 138, and 141.

Piston valves, as usually fitted to models, allow no escape for trapped water. A slide valve will lift, but a solid piston valve cannot, and the starting of a model locomotive provided with the latter valves may often prove troublesome. However, where a solid piston valve has no lap or lead, such difficulties will not as a rule arise, as there is no 'compression' stage in the stroke. Small models need practically no lap, and if lap equal in amount to one-quarter of the width of port in engines up to three-quarter scale is provided, the engine will be found to work quite sweetly, no lead (*i.e.* port opening when the engine is on dead centre) being necessary. In larger engines the lap should not exceed half the width of the port, viz., for $\frac{3}{16}$-in. steam ports provide $\frac{3}{32}$-in. lap.

The valves for cylinders of the 'Dunalastair' model on page 120 are provided with a large amount of lap, and if an engine were built exactly to drawings it would be found that the eccentrics would have to be very large to open the port sufficiently, and that the admission of the steam would almost certainly become 'late,' after the engine had been running a short time, owing to 'lost motion'—the many joints in the link motion, each with its necessary working slackness, giving a travel smaller than the drawings indicate.

The best remedy for this is to reduce the lap to half the amount shown on the drawings, which should prevent loss of power, and the annoyance of having what is termed a 'blind' running engine.

The recesses of the stuffing boxes of model steam engine cylinders should be as deep as possible, so that a good body of packing may be installed, and should be fitted with short glands so that any binding action on the rod, due to the unequal screwing up of the studs, is prevented, or at least lessened.

For the same reason—viz., the liability of binding the rods or spindles—the use of the common screwed glands (see fig. 139) is to be deprecated in many cases, and unless the glands can be accurately screwed and the recesses truly tapped, should not be employed at all.

From an amateur's point of view the studded gland is easier to make, and is also more in accordance with actual practice.

Where it is desired to do away with a motion plate (see the design on Plate III.) dummy glands for the tail end of the valve spindle are advisable. The difficulty of getting three bearings in a line precludes the use of dummy glands where a motion plate *is* to be used, and it should be borne in mind that unless the support of a motion plate or a dummy gland is given to the valve spindle, glands will constantly be in a leaky condition.

Steam Port and Pipe Proportions.

Owing to the very low piston speeds even at the highest rates of travel, the ports of model locomotive engines need not be so large as a mere reduction of scale would render necessary. Again, as the cylinders of the model are much smaller than the scale size, ports may be made less in width and length than at first sight would appear advisable. For models a good rule is

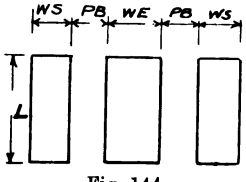


Fig. 144.

For models of one inch scale and smaller:—

L = half diameter of cylinder × scale of model + $\frac{1}{16}$ in.

WS = $\frac{1}{16}$ of the stroke.

WE = $\frac{1}{8}$ of the stroke.

PB = $\frac{1}{16}$ of the stroke.

For larger models:—

L = half diameter of cylinder.

WS, WE, and PB as above.

Therefore for a $\frac{3}{4}$-in. scale model with $\frac{7}{8} \times 1\frac{1}{2}$-in. cylinders, the dimensions would work out as follows—

L = $(\frac{1}{2} \times \frac{7}{8} \times \frac{3}{4}) + \frac{1}{16} = \frac{25}{64}$ in., or, say, $\frac{3}{8}$ in.

WS and PB = $\frac{1}{16} \times 1\frac{1}{2} = \frac{3}{32}$ in.

WE = $\frac{1}{8}$ of $1\frac{1}{2} = \frac{3}{16}$ in.

Steam pipes should have an internal diameter at least about one-fourth of the diameter of the pistons; therefore for 1-in. cylinders $\frac{1}{4}$-in. pipe (internal bore) should be employed, and for $\frac{1}{2}$-in.

cylinders $\frac{1}{8}$-in. bore, for $\frac{3}{4}$-in. cylinders $\frac{3}{16}$-in. bore. Exhaust pipes and passages should be one-tenth the area of the piston wherever possible, although in small models both the steam pipe and exhaust pipes may have slightly smaller internal diameters than the above rules would dictate.

Cylinders for Compound Locomotives.

As the question of compounding has already been considered and the cylinder proportions determined, the various arrangements may now be descanted upon.

The excellent two-cylinder type, which may be very well applied

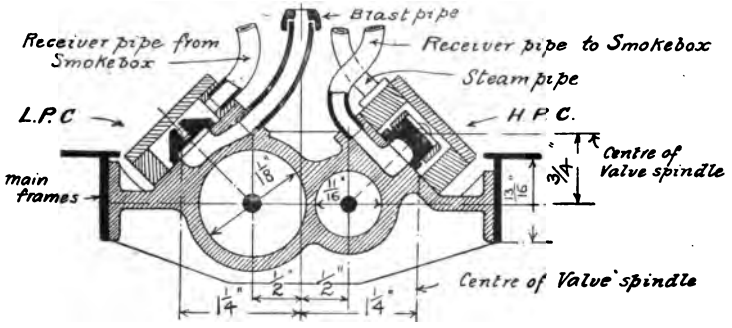


Fig. 145.—Two-cylinder Compounding applied to an Outside-framed $\frac{5}{8}$-in. Scale Engine.

to either an inside or outside-framed locomotive (the latter is the simpler task), is shown in fig. 145.

If an inside-framed engine is chosen, the steam chest and glands should extend right outside the main frames, an arrangement of valve gear being schemed to suit the position.

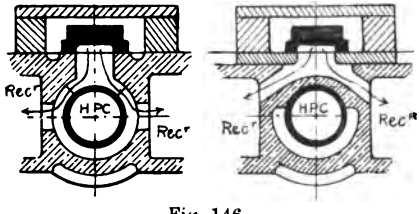


Fig. 146.

A modification of Mr. Smith's system of compounding, employed on the Midland and North-Eastern Railways, is shown in fig. 147.

The high-pressure steam chest is placed on the top of the cylinders and actuated by the central valve motion through the medium of a rocking shaft and exhausts into the jacket of the H.P.

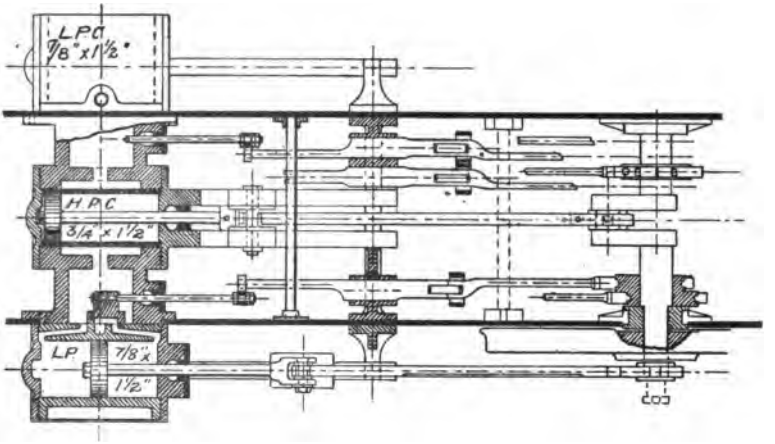


Fig. 147.—Cylinders for Model 'Smith' Compound.
(Designed by Mr. J. P. Meaden.)

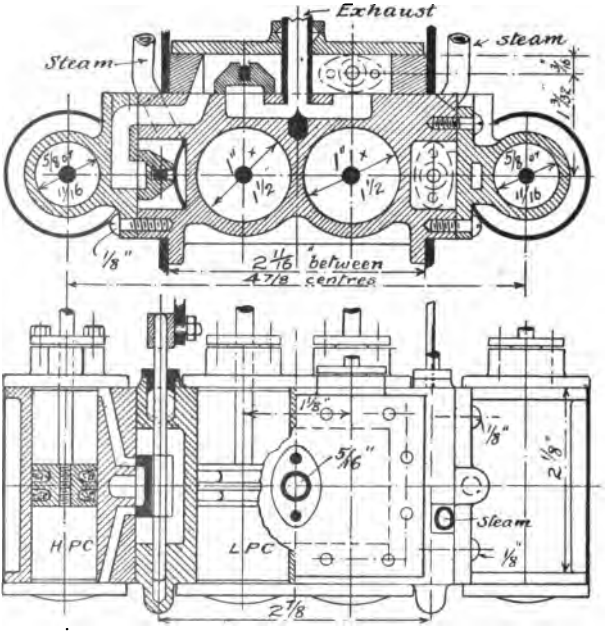


Fig. 148.—Cylinders for Model London and North-Western Railway 'Webb' Compound.

cylinder, thence through holes into the L.P. steam chest. Whilst this is an ingenious way out of the difficulty, the writer would prefer to leave the jacket space quite free from contact with the exhaust steam, a course which can be easily arranged as shown in fig. 146.

A four-cylinder compound of the L. & N.W.R. 'Black Prince' type may be built having cylinders arranged as shown in fig. 148, no special difficulty of construction arising. The drawing is prepared to suit a $\frac{3}{4}$-in. scale locomotive, and *slip eccentric* valve gear is strongly recommended. If a gear capable of reversing from the

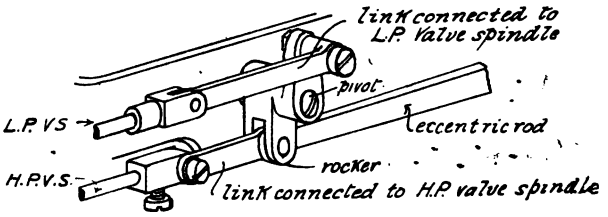


Fig. 149.—Rocking Shaft for Model 'Webb' Compound.

cab is desired, then the best course will be to follow the prototype, using Joy's gear on the L.P. connecting rod, the H.P. valve obtaining its motion from a rocking lever attached to the tailed end (front) of the L.P. valve spindle.

As the design stands, a single eccentric outside the cranks (see fig. 196) should be attached to a rocking lever as shown in fig. 149, the uppermost arm working the L.P. valve and the lower one the valve of the H.P. cylinder. The cranks of the H.P. and L.P. cylinders on each side respectively should, of course, be exactly opposite one another, each pair of engines being placed at 90 degrees with each other.

Oscillating Cylinders.

Small oscillating cylinders as a rule control the distribution of the steam without separate slide valves, and as the vibrations which open and close the ports are at right angles to axis of the cylinder at the dead points (*i.e.* to the centre line of the motion work), it will be seen that no advance in steam admission and exhaust is possible, and therefore oscillating engines should be

used only for the smallest models. Again, as the steam pressure at certain points in the cycle tends to force the cylinder off the face of the steam-distributing block (no closed steam chest being employed) the steam pressure and the size of engine is limited, and models larger than $\frac{5}{8}$-in. scale should not be provided with such cylinders.

The up-and-down movement of properly spring-borne axles affecting the steam distribution of oscillating cylinders, plain bearings

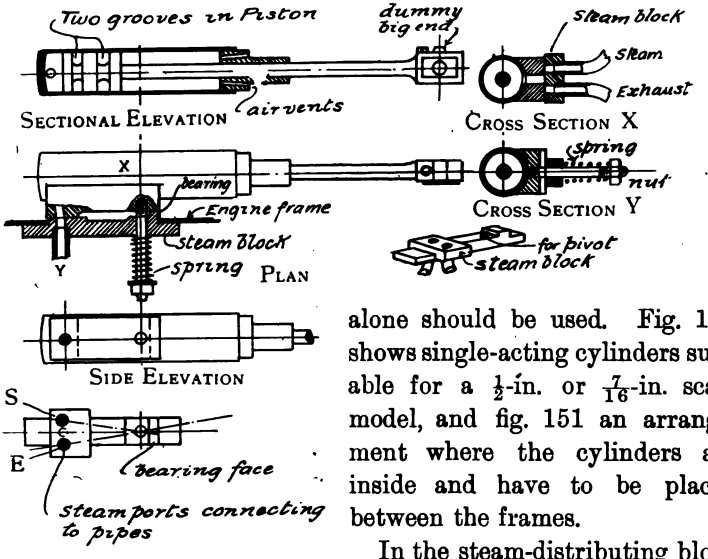


Fig. 150. — Single-acting Cylinders for ½-in. Scale Model Locomotive.

alone should be used. Fig. 150 shows single-acting cylinders suitable for a ½-in. or $\frac{7}{16}$-in. scale model, and fig. 151 an arrangement where the cylinders are inside and have to be placed between the frames.

In the steam-distributing block two holes are necessary — one connected to the boiler and the other to the exhaust pipe in the chimney, or to a reversing block (see next chapter) where the engine is to run both backwards and forwards.

The crank pins for single-acting locomotive cylinders should be placed at 180 degrees apart, that is, directly opposite to one another.

Fig. 152 illustrates a design for a double-acting cylinder the steam block of which renders the engine capable of being reversed from the cab. This property, while making it possible to dispense with a regulator—as in the mid position of the lever steam is shut off

from the steam-distributing block—is considered by some as very desirable. Those who require a simpler cylinder than the one described below may use a steam block without a reversing cock.

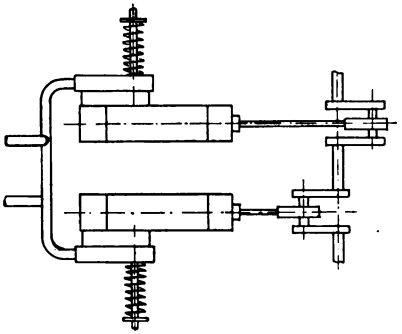


Fig. 151.—Single-acting Oscillating Cylinders placed Inside the Frames. (Scale, half full size.)

The steam block has two main passages, the starting holes of which must be plugged up after drilling. A centre passage parallel with these must be drilled as far as the steam entry, the outer end of which forms the connection for the exhaust pipe. At exactly right angles to the latter passage and crossing it at the four-way cock, a hole must be drilled connecting the upper and lower long passages, entry of the drill for this being likewise plugged. Four ports are required, and may be drilled from the back as shown in section B B. The reversing

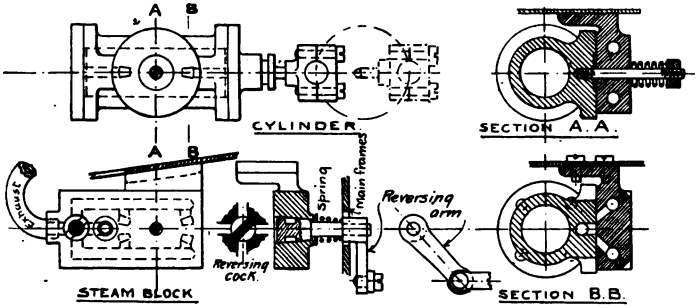


Fig. 152.—Reversible Double-Acting Oscillating Cylinders.

cock is connected by an arm to the reversing lever, which, if it is revolved through at quarter of a turn, will change over the top and bottom passages (and ports) from exhaust and steam as they are in the drawing, to steam and exhaust respectively, thus reversing the engine.

This type of cylinder was intended to be used in the single-cylindered four-wheeled design given on page 251.

In setting out the ports and erecting oscillating cylinder models it must be borne in mind that the passage to the cylinder should not in any case allow communication between the two ports of the steam block; thus the space between the latter ports should just cover the hole in the cylinder face. The cylinder should be placed so that the ports are in the central position (when the

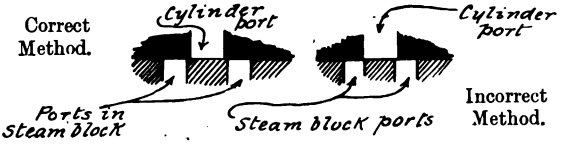


Fig. 153.

engine is on its dead centre), as shown at S and E in fig. 150, the centre dotted circle representing the position of the cylinder port.

Care should be taken to see that two faced portions of the cylinder and block are so disposed that the pull of the spring on the pivoting stud ensures perfect contact between the port faces. This point is provided for in the cylinder by filing away one of the faces coming together at the pivot in such a manner that the bearing is beyond the pivot and farthest away from the steam faces, as shown in the plan, fig. 150.

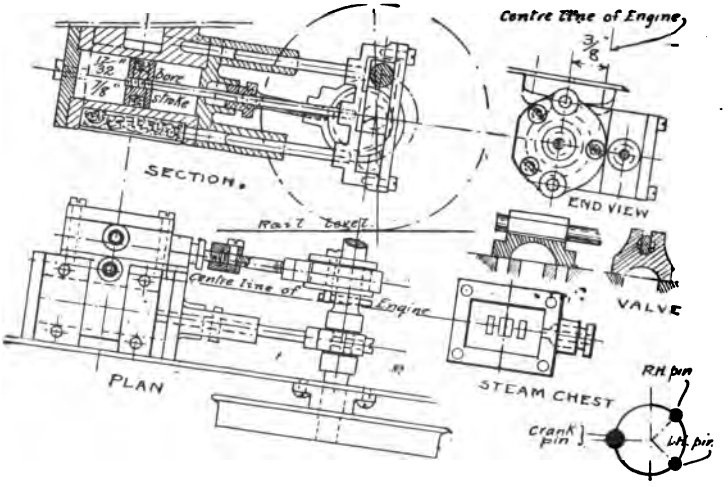


Fig. 154.—A Cylinder with Slide Crank.

CHAPTER VIII.

Valve Gearing.

While many makers of model locomotives have clear ideas upon the subject in general, a complete knowledge of the action of the slide valve and the design of the required gearing is often lacking. There is hardly a more important feature in the whole engine, and upon the design, manufacture and adjustment of the valves and valve motion the ultimate success of the machine depends. A very slight defect will either render the model less efficient as a steam engine—*i.e.* it will use more steam than the power developed should warrant—or cause the engine to fail absolutely.

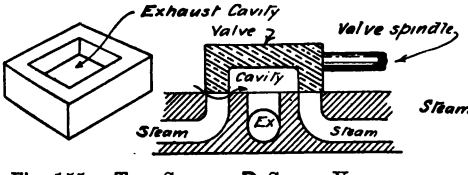


Fig. 155.—The Simple D Slide Valve.

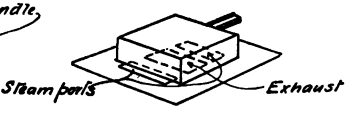


Fig. 156.

Therefore it behoves the beginner to thoroughly understand the principles governing the action of slide valve, and study the variations in the working of the locomotive that slight differences in the proportions and setting will make. A locomotive slide valve may be likened unto a hollow rectangular box with thick walls, one side of which has been removed and the cavity exposed, sections at right angles to the open side being similar to the letter D turned on its side. For this reason it is commonly called the D slide valve.

The open side of the valve slides up on the 'valve face' of the cylinder, which is provided with three ports, the central one

('exhaust port,' the largest in width) being connected to the atmosphere by the blast pipe,[1] and the others ('steam' ports) each with the respective ends of the cylinder. As the valve moves backwards and forwards in the closed chamber called the 'steam chest,' which is placed in communication with the steam space of the boiler at the driver's will, it alternately opens and closes each 'steam' port to the steam in the chest, never under any circumstances opening both at the same time. It will be seen that the steam passing through the port when it is opened by the valve and entering the cylinder will press on that side of the piston doing work in propelling it forward. The piston being, as it were, fastened to the wheel by the crank, connecting rod and piston rod, causes the engine to be moved forward or backward according to the relative positions of these parts, and also to which port is opened.

At the same time that the steam chest is open to the one steam port the other will be in communication, by means of the cavity of the slide valve, with the large central 'exhaust' port, and the piston will, at the same time as the steam is passing away, be receding. The importance of providing a free exit for the steam from the cylinder will be evident, and just as much care must be taken in allowing the exit of the steam to take place at the proper time and in a proper way, as in arranging its admission to the cylinder.

Fig. 155 shows a valve more suitable for the smaller classes of model locomotives in which the edge of the valve only just covers the steam port, projecting a trifle over the steam port on to the valve face beyond, to prevent the blowing through of steam to the exhaust cavity as indicated by the arrow. The slide valve is also illustrated, turned upside down to show the cavity, and, in the other perspective drawing is shown resting on the valve face of the cylinder with the port nearest to the reader 'open to steam' (fig. 156). The manner in which the exhaust passage is conducted to the outside of the cylinder casting is also indicated.

These remarks and sketches, the writer thinks, explain the elementary difficulties in the construction and arrangement of the

[1] The extremity of the exhaust pipe in a locomotive is always called the blast pipe.

simplest form of slide valve, and to enable the next gulf to be bridged, the reader's attention is directed to fig. 157. Here are a series of views of the different positions of crank, piston, eccentric, and valve which will readily make clear the latter's various 'phases.' The valve is of a type known as the simple slide valve, and in fig. 157 (A) is shown covering both ports, allowing neither the entry nor the exit of steam to or from the cylinder. At the same time the piston is at the end of its stroke, the crank on 'dead centre,' and not capable of exerting any turning movement to the axle. In diagram (B) the valve has moved from left to right, and during the time which would elapse in the changing from position (A) to position (B), has been admitting steam from the boiler (*via* the steam chest) to the left-

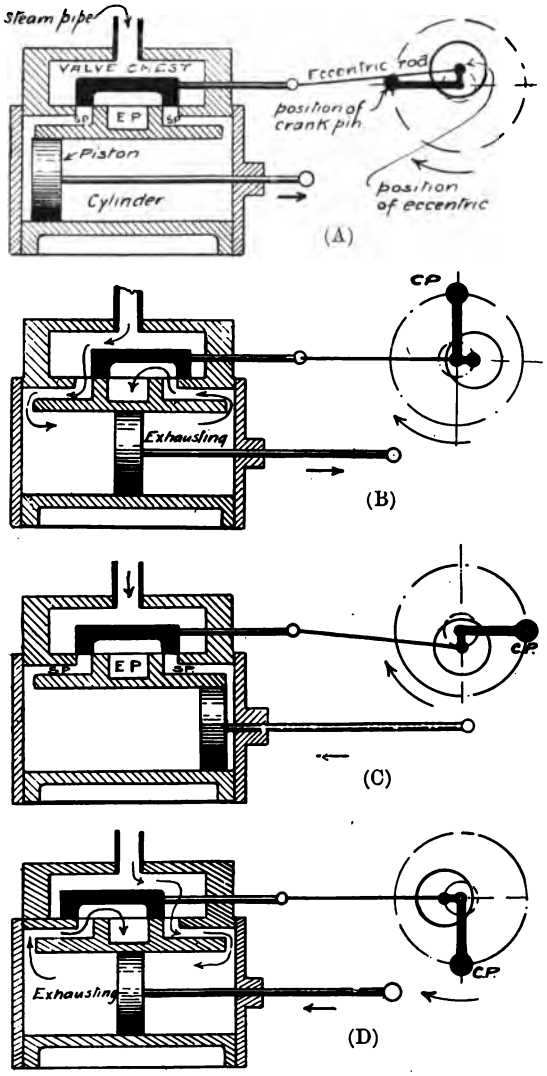


Fig. 157.—A Cycle of Operations.

hand side of the piston, forcing it to the right. The valve is open to its maximum at this point of the cycle, and the crank pin C.P. being at the 'top centre,' is in the position when the turning effort on the shaft will be greatest. The other end of the cylinder, it must be noted, is 'exhausting' any steam remaining in the cylinder from the previous stroke. Diagram (C) shows the exactly opposite position to diagram (A). The crank is on what is called in locomotive work its 'back dead centre,' and simultaneously with the movement of the piston the opening of the right-hand or 'back' end of the cylinder to steam, and the exhausting of the steam previously admitted to the left-hand side of the piston will commence. The openings of the valve to both exhaust and steam on each side of the piston respectively are shown at the maximum

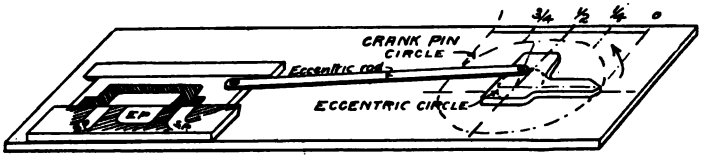


Fig. 158.—A Model for Working out Slide Valve Problems.

in diagram (D), which is the opposite position to that depicted in drawing (B).

It must be noted that the eccentric leads the crank, and the amount of its advance is exactly *one quarter* of a complete revolution, *i.e.* 90 degrees. If a paper or wooden model of the gear be constructed, it will be seen that the valve does not cut off the steam until the end of its stroke, that it does not admit or exhaust until the stroke has commenced, and also that a *complete cylinderful* of steam at boiler pressure is employed at each stroke, the expansive properties of the steam not being in any way utilised by this valve gear. Postponing for the time being the further investigation of the movements of the slide valve in relation to the piston and crank, the writer will describe the construction of a valve-gear model which enabled him as a beginner to thoroughly grasp the action of the slide valve and to work out various problems in valve gear which from time to time presented themselves. No miniature locomotive builder should be without one of these models unless he possesses some arrangement which will serve a similar purpose,

and the excuse that such a model is difficult to make is not in this case tenable.

The valve gear model consists primarily of a 7 × 1 in. board, which should be planed at least one side, and will be better if it has two or three cross battens on the back to prevent it warping.

The revolving T-shaped piece of wood should be dry and of hard material, and although an ordinary wood screw passed through a hole in the wood will serve as a pivot, the bushing of the centre with a piece of brass tube is an improvement. The pivot screw should be flush with the revolving T-piece, and be provided with a small centre-pop exactly in the centre. From this compasses may be used to set out various eccentric throws, angles of advance and other points. The point of the T-piece should just touch a large circle which is to be used as the crank-pin path, and from this point to the centre pivot a line should be marked on the T-piece which shall coincide with a horizontal centre line from end to end of the apparatus. On the T-piece a line vertical to the foregoing should also be marked in a manner which will render it indelible.

At the outer end of the board two V strips of hard wood should be fixed to the board, and between these another piece of hard wood should be truly planed up so that it will slide to and fro easily, and without shake. A rod as long and as stiff as possible should connect the sliding piece and the revolving T-piece, the length being such that when the T-piece is in the position in sketch, fig. 158, the sliding piece upon which a section of the valve should be marked, is in its central position. The lower of the fixed V-pieces should have the ports marked upon it as also indicated in the sketch.

All the variable parts of the model may be arranged to receive cards for the various problems which may from time to time arise, these cards being removed and filed for future reference. Indeed there are many possibilities for the improvement and embellishment of this model, but these will be left to the reader to accomplish. Above the crank-pin circle a conveniently divided line the length of the stroke should be incised on the board, perpendicular lines being dropped to

cut the crank pin circle, by the aid of which, for any position of the crank, the position of the piston may be read off at a glance.

The possession of such a model will allow the reader to readily study the intermediate 'happenings' not shown in the four diagrams in fig. 157, as well as to settle the more important problems of link reversing motion, as will be shown later in this chapter.

The steam-engine is rendered much more economical if the admission of live steam from the boiler is cut off at a point in the stroke earlier than is possible with the simple valve; the steam being imprisoned in the cylinder and forcing the piston along by its expansive action and without further supply. Whilst this method of economising steam cannot be carried very far in a miniature locomotive, there are many reasons why, in the larger models especially, an early cut-off should be employed. The early cut-off and expansion of steam are obtained by a slight addition to the outer edge of the simple valve. This increase in size is known as 'lap,' because it overlaps the ports when the valve is in mid position (see fig. 159), and, by the way, involves considerations of vast import in the design of steam engines.

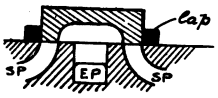


Fig. 159.

If the model already described is to hand and upon it is drawn the simple valve together with its ports, it will be seen that without altering any other part of the gear, if lap to the extent of, say, half the width of the port be added to the valve, not only will the port opening be reduced but the admission will also be late, and according to the amount of 'lap' added, will not occur until *after* the crank has passed the dead centre and the piston is well on its way along the cylinder. Fig. 160 will explain this.

Therefore the alteration of the eccentric sheave throw and position on the shaft is required. The first step is to give an *increased travel.* To arrive at this, the dimension representing the amount of lap must be added to the port opening. In models it is generally advisable to make the throw of the eccentric (*i.e.* the distance from the centre of the shaft to the centre of the eccentric

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sheave) equal to the width of the port *plus* the amount of the lap.[1] The rule stands thus:—

$$\text{Travel of valve} = \text{Lap} + \text{port width} \times 2.$$

The reason the sum of the lap and the port opening is multiplied by 2 is that the valve moves equally on each side of its central position, and that the amount of the lap *plus* port-opening gives the movement to one side of the centre only.

The next point to consider is the position of the eccentric on the shaft and the consequent position of the valve when, say, the piston is at the end of its stroke and the crank on dead centre. It is a *sine qua non* that the valve should in the latter circumstance be either about to open the port to steam or that admission shall have commenced.

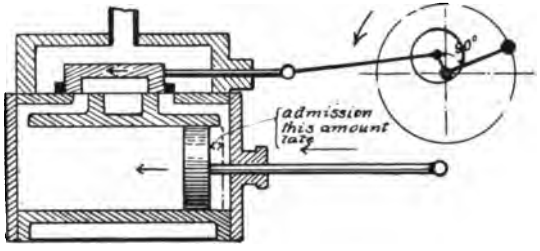


Fig. 160.—Late Admission, due to the Addition of Lap only without advancing the Eccentric.

Presuming for the moment that the valve is *about to open* when the piston is at the end of its stroke: having calculated the proper throw of the sheave, it will be found, by use of the model or a carefully set-out diagram, that the eccentric sheave must be moved further away from the crank than in the case where the simple valve is employed, and in relation to the crank, will stand at an angle greater than a right angle.[2] The difference between the angle of 90 degrees and the angle at which the sheave has to be placed is termed the *angle of advance*, and is symbolised by the Greek letter θ. The horizontal distance in which the eccentric has to be moved is equal to the lap, and is marked A in fig. 161.

In large engines it is necessary to time the admission of steam earlier than at the dead point in the stroke, and to this end the sheave is given a still greater angle of advance. The horizontal

[1] The lap is amount the valve overlaps the steam port *on each side*, therefore the valve is wider than the over-all width of the ports by an amount equal to twice the lap.

[2] An angle of 90 degrees is termed a right angle.

distance is found by adding the extra advance necessary for the amount of admission (called the lead of the valve) to that already provided for the lap.

Therefore, where such an early admission is required the advance of the eccentric over and above the advance of 90 degrees should equal—

Lap + lead.

However, it will not be found necessary, except in model locomotives above 1½-in. scale, to provide *lead*, and even then only about $\frac{1}{32}$ in. is required.

The addition of lap to the valve and the advance of the eccentric give to the valve several new duties, which may be enumerated:—

(1) Earlier cut-off.
(2) A period in which the steam is imprisoned in the cylinder.
(3) An earlier release or exhaust.
(4) Closes the exhaust earlier, and by this means imprisons the remaining steam in the cylinder whilst the piston recedes, giving a period of *compression*.
(5) Where the valve is provided with lead the next admission occurs before the piston commences its stroke, increasing the cushioning effect.

For a deeper study of the effects produced by lap and lead the author must refer the reader to Mr. W. J. Tennant's handbook on *The Slide Valve*,[1] and urge the use of the described model, upon which problems should be worked out, arranging different angles of advance with varying amounts of lap. To help in this direction, however, the writer includes herewith a diagram similar in general outline to that on page 137, showing five relative positions of crank, piston, valve and sheave, at each of which something different is happening in the cylinder, and the only instruction that may be given in explanation is that the beginner should at first only consider the action of the valve *on one side* during a complete cycle of operations. This method will cause less confusion than if an attempt is made to grasp what is going on on both sides of the piston at the same moment. Imagine for the time being that the cylinder is a single-acting one, and when the movements and the

[1] *The Slide Valve Simply Explained*, price 6d.

results of the movements of the valve over the ports for a given side are mastered, the rest will be an easy matter.

Many readers may consider some of the foregoing remarks of a character simple to an absurd degree, but the writer felt it was better for him to start at the beginning, assuming that nothing is known of the subject, than to give the tyro credit for even a slight knowledge of the slide valve and its functions.

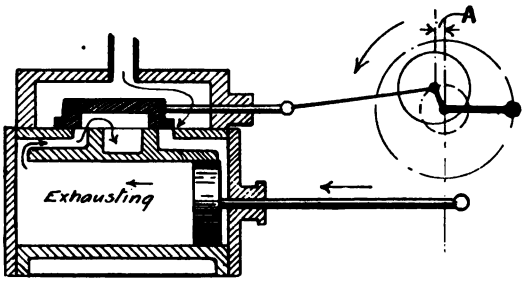


Fig. 161.

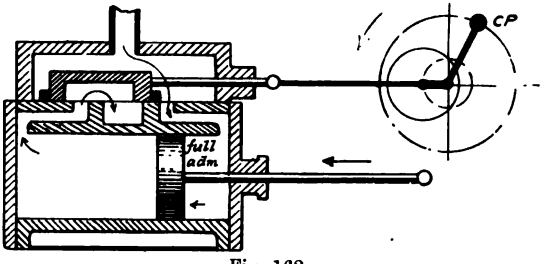


Fig. 162.

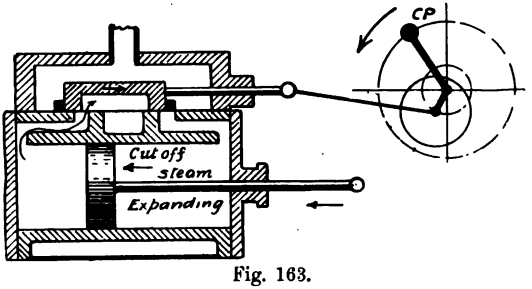


Fig. 163.

Prospective model locomotive builders may perhaps ask, How much lap shall be provided? In small models this should never be more than $\frac{1}{32}$ in., and where reversing gears of a type which do not allow of an angular advance, lap cannot be added to the valve. In engines of 1-in. scale and above, the lap should be about half the width of the port. Where a greater amount is given to the valve, the engine will most likely not start readily—that is, with valve gear dimensions common to model locomotives. Whilst in large practice the valve never opens the steam ports to the fullest extent, it is, however, advisable to allow the valve to uncover the whole of the steam port when the engine is new. Where link

motion is employed the writer generally sets out the motion to give an even greater movement in full gear. By this means it is possible to arrange the full gear notches on the reversing lever or screw a little closer to the centre one than otherwise will be found necessary; and if at any time, through the wear of the pins, etc., it is desired to increase the valve travel, the full gear notches may be extended. This course will render large sheaves and links imperative, and to make the parts proportionate the eccentric rods should be as long as possible; indeed, in reality all this means is that the link motion should be made larger than a scale reduction would admit. A good example of this practice is shown in the valve motion for a 2-in. small tank locomotive (see Plate I.), which, by the way, was found to work excellently in practice. The engine could be notched up three points (the next notch to the centre), where it would run with a perfectly regular 'beat.'

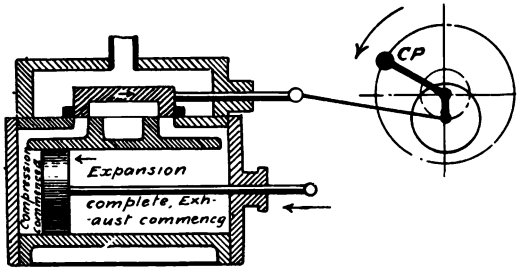


Fig. 164.

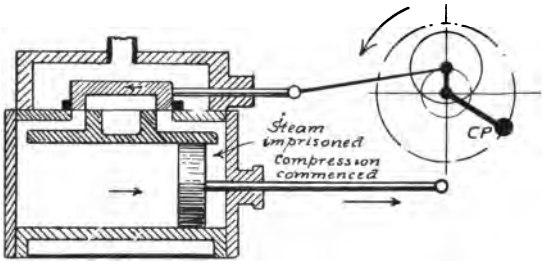


Fig. 165.

The increase in the scale of the motion may be judged by the fact that whereas the scale throw of the eccentrics of a real engine of the same type works out to about $\frac{17}{32}$ in., and the length between the end pins of the curved link and the length of eccentric rods to $2\frac{3}{4}$ and $8\frac{1}{4}$ ins., the respective dimensions in the model are $\frac{11}{16}$ in., 4 in. and $10\frac{7}{8}$ in.

Amateur engineers when setting out the link motion of a model locomotive are often at a loss to fix the proper throw of eccentric sheave necessary for a given travel of the valve. Where the

curved link is of the pattern shown in fig. 167, the travel of the eccentric will be equal to the travel of the valve, which has already been fixed at 2 × lap + port-opening; therefore the throw of the eccentric will be exactly half the valve travel, or equal to the lap *plus* port opening. The radius of the link will equal distance (*a*) *plus* the length of the rod (*b*), and if the slot is made long enough, extra valve travel can be obtained.

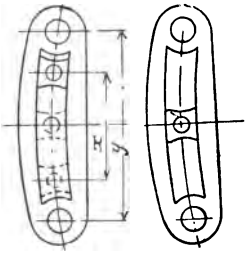


Fig. 166.

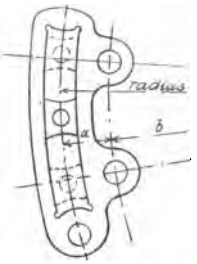


Fig. 167.

THE TWO KINDS OF CURVED LINKS USED IN LOCOMOTIVE PRACTICE.

In the type of link more commonly used in English locomotives and illustrated by fig. 166, the eccentric rod not being in a direct line with the valve spindle when the engine is in full backward or forward gear, the link acting as a lever reducing the valve-spindle (and therefore valve) travel, a greater eccentric throw will be necessary.

The difference in the travel of the eccentric and valve respectively depends upon the proportion of the leverage, *i.e.* to the rela-

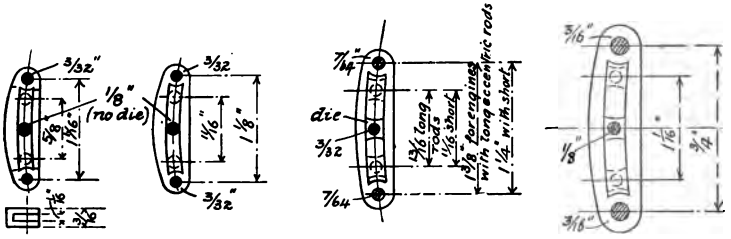


Fig. 168.—PROPORTIONS OF CURVED LINKS FOR MODEL LOCOMOTIVES.

tive distances between the eccentric rod pins (*y*) and the centres of the die in its highest and lowest positions (*x*), fig. 166.

As has already been hinted, it is always the best practice to make the link motion a little larger than the scale of the model would otherwise determine, and as a guide to builders of model locomotives, links suitable for locomotives of various sizes are given

in fig. 168, to a scale of half full size, the maximum movement of the die blocks being indicated.

Taking as an example a valve gear where the dimensions of the curved link are $1\frac{1}{4}$ in. and $\frac{11}{16}$ in. respectively and the required travel of the valve say $\frac{9}{32}$, the problem may be worked out arithmetically thus:—

As y is to x so is ET to VT.

Where y is the distance between the eccentric rod pins,
x is the working distance of the die in the slot,
ET is the required eccentric travel,
VT is the valve travel.

The terms of x, y, and ET are known, and the sum is solved thus—

$$ET = \frac{VT \times y}{x}.$$

$$ET = \frac{\frac{9}{32} \times 1\frac{1}{4}}{\frac{11}{16}}.$$

$$ET = \frac{45}{88}, \text{ or } \frac{1}{2} \text{ in. full.}$$

A method which will appeal to those practical men to whom the simplest problem in mathematics is a task to be avoided is given on the diagram (fig. 169). This diagram may be of any dimensions—twice, four, or ten times full size—and may be applied to the valve-gear model illustrated on p. 138. The example to be worked out is one where the proportions of x and y of the link are $\frac{3}{4}$ to $1\frac{1}{4}$, or 3 to 5.

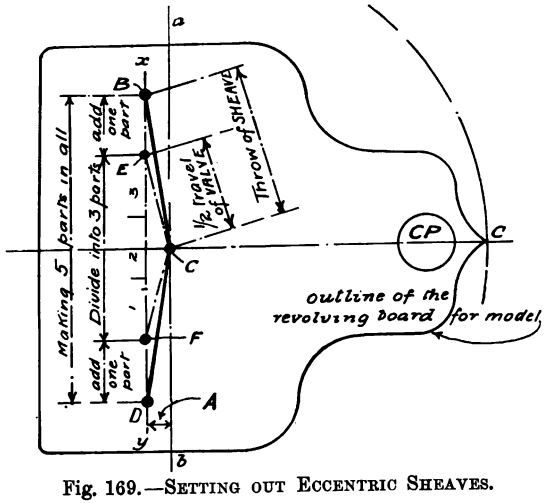


Fig. 169.—SETTING OUT ECCENTRIC SHEAVES.

Having drawn the centre lines $a\,b$ and C c at right angles to each other as shown, C being the centre pivot, and C P the crank pin position,

determine the amount of the advance[1] A and at this distance draw the line *x y* parallel to *a b*. The line must, of course, be on the opposite side of *a b* to the crank pin, except in special cases, as, for instance, where a rocking shaft is employed. From the centre C mark points E and F, the distance from both points to the centre C being *one-half of the travel of the valve.* Divide the distance between E and F into three parts (as there are three quarter inches in the distance the die block moves in the curved link). The dimension between the eccentric rod pins being $1\frac{1}{4}$ in the case in point—*i.e.* five quarter inches—all that is necessary to get the required travel of the eccentric sheave is to add another part to the line *x y*, one upward and one downward from points E and F. This gives points B and D on line *x y*, the distance from B C and D C being the required throw of the sheave.

The action of the link motion may be studied with the aid of the model by drawing on the revolving T-piece or on a piece of card which can be attached to the T-piece, the lines *a b*, *x y* and C *c* shown in the previous diagram, and also adding, not regarding what kind of curved link is employed, the points E and F, the distance E C and F C being, of course, half the travel of the valve.

Divide the *x y* line between points E and F into as many notches as the reversing lever contains, and then the action of the valve may be studied in back gear or fore gear, and also when the gear is 'linked up.' The changes in the expansion, exhaust, and compression stages may be observed without the trouble of making elaborate diagrams. The small circles on the line *x y* show the different positions of the lever, and, by means of a movable stud or pin in the eccentric rod, the latter may be inserted in holes drilled in the revolving T-piece as indicated by the numbers. Position P shows the engine in fore gear, the third notch from the centre, Q in full back gear. The writer would urge his readers to make this addition to the described valve model and note what

[1] As 'lost motion,' due to slackness of joints, gives a late port opening, the lap may be of the fullest dimensions with same amount of advance, the builder cutting off the lap if after the engine is built the travel is reduced very much by the inevitable slackness or if the admission occurs at a later period than it should do. Another way is to fix the lap, for a $\frac{3}{4}$-in. scale engine say, at $\frac{3}{16}$ in. providing an advance of $\frac{1}{8}$th. This, of course, should give *lead.* In practice, however, the lead will be nullified by the aforesaid lost motion.

occurs as the engine is linked up. One thing should strike him forcibly, and that is that the *time of admission* is practically not changed for any position of the reversing lever; but the cut-off, extent of the expansion period, moments of exhausting, and the commencement of the compression stage, vary widely with different positions of the lever.

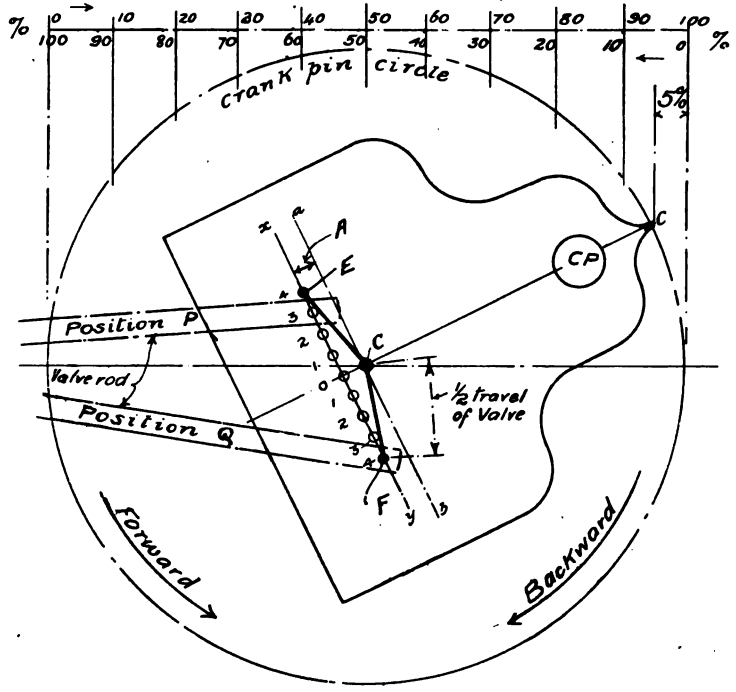


Fig. 170.

Whilst the inventive genius should not be discouraged, the writer would not advise attempts to put into practice a reversing valve gear based upon this model. The late Mr. David Joy patented a gear[1] in which a single eccentric is moved along the line EF in an ingenious manner, by fluid pressure, but no such arrangement has yet been devised embodying greater advantages than those of the ordinary link motion and which is capable of being actuated whilst the engine is running.

An arrangement which on small model locomotives gives all the

[1] Joy's oil valve gear; tried on a L.B. & S.C.R. engine.

advantages of link motion, except that it is impossible to reverse the engine whilst running, and that there is no intermediate position between full gear forward and full gear backward—*i.e.* between point E and point F in the foregoing figures—is known as the 'slip eccentric' reversing gear. Only one eccentric is necessary, and its rod is attached to the valve spindle direct. There are a very few joints, therefore little lost motion, and the construction of the gear is simple in the extreme. All that is necessary is the provision of suitable stops on the shaft, the eccentric being loose, these stops being arranged so that when running the sheave is at either of the points E and F (fig. 171), it continues to remain so until the engine is started by hand in a contrary direction. Slip eccentric valve gears are unreservedly recommended for engines of $\frac{3}{4}$-in. scale and smaller, and for all the first attempts at model locomotive building. When more experience has been gained, then link motion may be tried with advantage. Where the novice is building a large engine in which link motion is imperative, then the subject should be approached on the lines already described, or in any similar scientific manner.

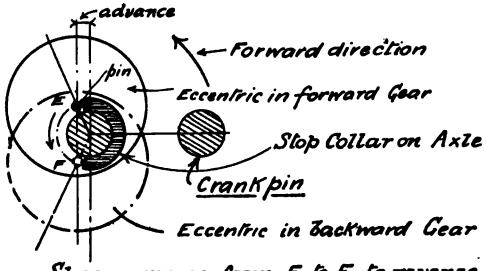


Fig. 171.—'Slip' Eccentric Gear.

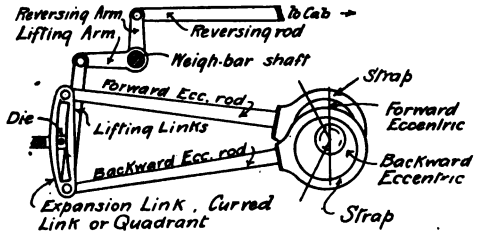


Fig. 172.

In all cases the work must be of the best, this being necessary in a higher degree with link motion. There is no adequate reason for link motion in an engine smaller than $\frac{3}{4}$-in. scale—that is, if an engine, which shall be a reliable and efficient working model locomotive, is the chief desideratum.

Before concluding the remarks on link motion, readers are

referred to the several drawings depicting this type of valve gear contained within these covers, which will, with the sketches, figs. 172 and 173, help towards a clear idea of the general arrangements of Stephenson's link reversing gear as applied to locomotives. Fig. 172 gives the names of the various parts, and fig. 173 shows the gear in the positions of full gear forward, mid gear and full gear backward.

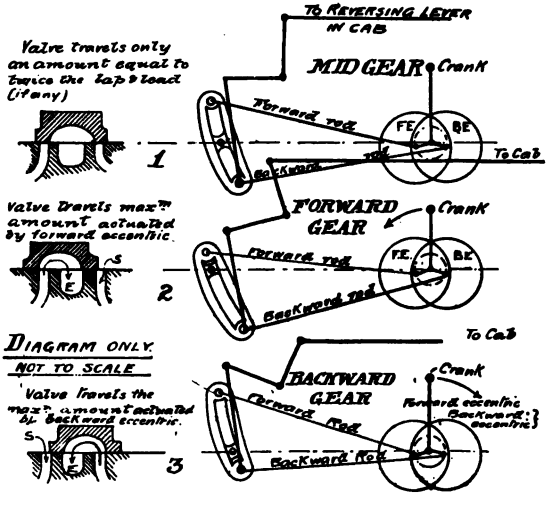


Fig. 173.—Stephenson's Link Motion in three Positions.

There are several points with regard to the setting of valves actuated by link motion which have been found by the writer to conduce to a good distribution of the steam, and may be enumerated as follows:—

(1) Eccentrics should have the proper throw (*with link gear; if they are provided a little in excess of the theoretical throw, trouble with regard to lost motion, and wear and tear of pins and straps, will not present itself*).

(2) The eccentrics must be in the correct positions on the shaft and have the proper angle of advance. (*Measure the lap of the valves after the cylinders are finished, in case of variance from the design.*)

(3) The eccentric rods must be of exactly the same length. (*The method of adjusting eccentric rods at the valve setting is not a good one, and should in no case be employed.*)

(4) The link should have the right curvature and the die should accurately fit the slot.

(5) The valve spindle must be capable of adjustment in length.

(*Various methods are possible, a screw adjustment being the best.*)

(6) The lifting links must all be of exactly the same length, and the arms of the weigh-bar shaft must lay in the same plane. (*Of course the weigh-bar shaft itself, in relation to the rest of the valve motion, must be erected accurately.*)

The first step to take in the operations of valve setting, supposing that all the work is finished and only requires erecting, is to fix up the crank axle on V blocks on the surface plate (or, in outside cylinder locomotives, with no crank axle to temporarily attach the wheels to the axle at the right angles to each other), and by the most convenient method set the crank pin on one side *vertically*. The eccentrics having a centre line produced to *their edges* (A), it will be then necessary to determine the amount of advance of the sheaves at these points, the two sheaves lying close together and preventing the setting being done from the centres. Having set the arm of the scribing block at the level of the centre of the axle-line B, drop the point as much as the angle of the eccentrics determines (C), and having the sheaves loose on the axle, turn them until the centre pops on the sheaves at A coincide with the point of the scriber at the lower level. Then fix the sheaves tightly for the time being, and proceed in the same manner for the other side. On erecting the motion, if the arms of the weigh-bar shaft are in the line with each other, and the lifting links and the *eccentric rods of dead length*, then all that will be required will be to set the valve in its proper position on the spindle, giving it an equal opening for both front and back ports. If the eccentric advance proves to be too much or too little, then the sheaves must be given smaller or greater advance in proportion, as it is generally found that owing to the angularity of the rods [1] the port opens to lead when it is not intended to, and if additional lap is

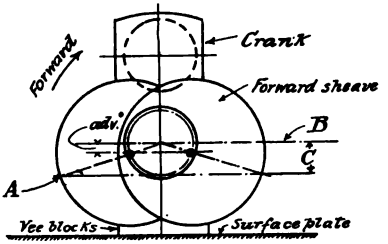


Fig. 174.—Setting Eccentrics.

[1] This is only so with engines having open eccentric rods. Engines provided with crossed rods give less lead in mid gear.

not desirable, then the advance of the eccentric must be lessened. Of course there is no reason why the differences in the port opening which arise in this way should not be taken into account at the setting of the eccentrics. Except in large models (*i.e.* 2-in. scale engines) and locomotives with short eccentric rods, the earlier admission, due to the angularity of the rods, is not noticeable and need not be considered. It is the writer's duty, however, to point out all the probabilities present in link-reversing gear.

The weigh-bar shaft and lifting arms and links, if already fixed, must be checked to see that, when the reversing lever is in full forward, backward, or mid gear, the curved links on each side places both links in similar positions at the same time; this being so, the valve may be coupled up to the spindle. Later, several devices will be described by which the valve may be moved along its spindle to adjust its relation with the ports. The best methods are those where screw threads are employed; at any rate the valve should not be fixed in the manner common to large locomotive practice, viz., the method in which the distance between the centre of the valve and the die block in the curved links is fixed, adjustment being made by shortening or lengthening the eccentric rods. The average amateur is sure to come to grief if he adopts this course, especially where the eccentrics are loose on the axle and are not fixed by the positive methods already described, as both eccentric rod length and sheave position have to be determined at one and the same time.

Whilst the valve setter is finding the proper place for the valve on the spindle, means should be provided to temporarily hold the reversing lever (where such is used) in the various positions, the notches not being cut until the last thing, and to ensure a good distribution of steam and a clear, regular 'beat,' the valve should be set with the lever in the usual running position. As the motion should be designed to give, when in full gear, a greater port opening than is required, plenty of clearance may be allowed between the die block and the end of the curved link, and under no consideration should it be attempted to run the engine with the lever fixed as far as it will go.[1] To ensure the accuracy of the

[1] Otherwise the pins of the motion will be subjected to shearing strains and may fail. For amount of clearance see fig. 168 and Plate I.

valve setting, the driving axleboxes should be locked in the true running position in the hornblocks by suitable pieces of packing.

Marks should be made on the frame at the various dead centres, a very good test for position of the sheaves in a model being to place the crank on dead centre and move the lever backwards and forwards. The valve spindle should not move during the reversal of the engine.[1] It will also be noticed that the valve will be just on the point of opening in forward, mid, and back gears when the crank is in this position (see page 148).

Model locomotives of $\frac{3}{4}$-in. scale and those of smaller dimensions do not as a rule require to be linked up, and therefore link motion can with advantage be dispensed with. Many model engineers, however, consider the lever in the cab a feature which cannot under any circumstances be sacrificed, and although the type of valve motions known as 'radial' gears[2] do not as a rule simplify matters, one or two arrangements suitable for small models which allow of the favourite method of 'reversing from cab' may be adopted.

None of the arrangements to be described are suitable for models of any size or for those to be ridden upon, and some do not allow of any lap or angle of advance. If the eccentric is advanced for the fore gear it will be found that the valve will be proportionately *late* in opening with the lever in back gear, therefore the eccentric sheave must be placed exactly 90 degrees in advance of the crank pin, and a simple valve (see fig. 155) employed.

One of the best methods is to use a reversing block in conjunction with piston valves, as is done in the case of some of the cheaper class of model locomotives.

In the cylinder face two holes (A B) connect with the steam and exhaust sides of the valve and the upper and lower holes shown with the steam pipe and exhaust pipe respectively. A vibrating reversing block is attached by a spring contact, in face of which two grooves are made as shown in fig. 175. These grooves connect passages A C and B D or B C and D A according to the position in which the block is placed by the reverse lever. An ordinary slide

[1] Theoretically the valve spindle should move, more or less according to the length of the eccentric rod. In a real locomotive the writer found the movement to be about one-eighth of an inch.

[2] Joy's, Walschaert's, and Hackworth's gears are called 'radial' valve gears.

valve cannot be fitted with this reversing arrangement, as when live steam is admitted to the exhaust port, the valve will be lifted off its face. However, this can be overcome if some method of holding the valve down is adopted, but this entails increased friction of the moving parts.

Another arrangement in which a single eccentric may be used, suitable for small models of under $\frac{5}{8}$-in. scale, is shown in the accompanying illustration, fig. 176.

No lap or lead is allowable, and the eccentric must be either 90 degrees in advance or behind the crank, according to whether the top or bottom position of the die block (radius link) is to be forward or backward gear. The lower position and the advance of the eccentric gives a forward motion to the engine in the above instance. The throw of the eccentric is worked out as in the case of link motion. There is not, however, any great saving of work in this motion, except for the eccentric, and in larger engines it should not be used. The gear is really a portion of the famous Walschaert gear shown in fig. 178, in which advance of the valve is obtained by use of a second series of levers, actuated from the piston cross-head. A model valve gear which may be said to be the modified Walschaert turned the other way about is illustrated in diagrammatical form in fig. 177. For mechanical reasons the curved link which is pivoted to the frames at the centre must be shaped as shown, so that the eccentric rod pin does not actuate the link when in mid gear. Otherwise the curved link would be forced off its pivot and the valve would, with the lever nearer to the central position, have more travel than in full gear, the opposite of what happens in ordinary link motion or in the valve-gear

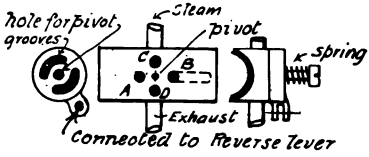


Fig. 175.—A Simple Reversing Arrangement.

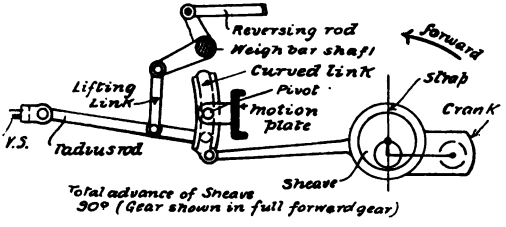


Fig. 176.—A Simple Reversing Gear.

depicted in fig. 176. Therefore full forward or full backward gear only is permissible.

By making a cardboard model the author found that although the eccentric cannot be advanced, lap and lead may be given to the valve, the necessary advance being obtained by the use of a long curved link and short eccentric rod. Mathematical accuracy in the opening of the valve is not attainable, but a gear made as described should be quite suitable for small locomotives up to $\frac{3}{4}$-in. scale. The driving axleboxes in engines having short eccentric rods should not be provided with very much vertical movement.

To set out Walschaert's valve gear, consider for the time being the total travel of the valve only. The eccentric should be placed at 90 degrees to the crank, and arranged to give the maximum port

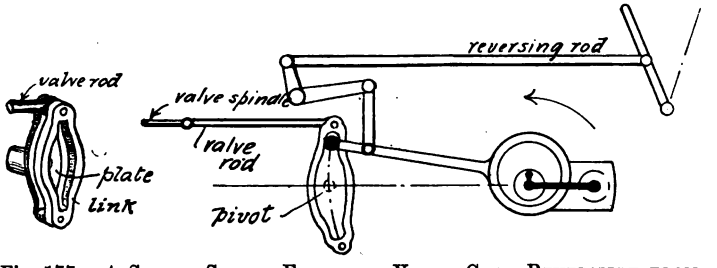


Fig. 177.—A Simple Single Eccentric Valve Gear Reversible from the Cab.

opening. The advance depends on the proportions of the vibrating lever A D (fig. 180), the distance A B equalling lap + lead × 2.

To obtain a small travel at A B is the difficulty in model work, as the required lead is generally 'nil' and the amount of lap small; therefore with the relatively large pins necessary it will not be found easy to get points A C close enough. With the design given, this trouble is not present; however, the levers are somewhat complicated in construction.

Another method is shown in fig. 179, where the distance between the points B and C may be reduced almost to nothing. As the function of the cross-head levers is to control the admission and the cut-off, a little greater movement than that which the drawing would dictate should be allowed in practice.

Joy's gear may be used with success in model locomotives, and neglecting the care necessary in the manufacture of the curved

slides, no great difficulty will be encountered. The method of setting out is rather complicated.

Beginners may be inclined to do without levers A and B and

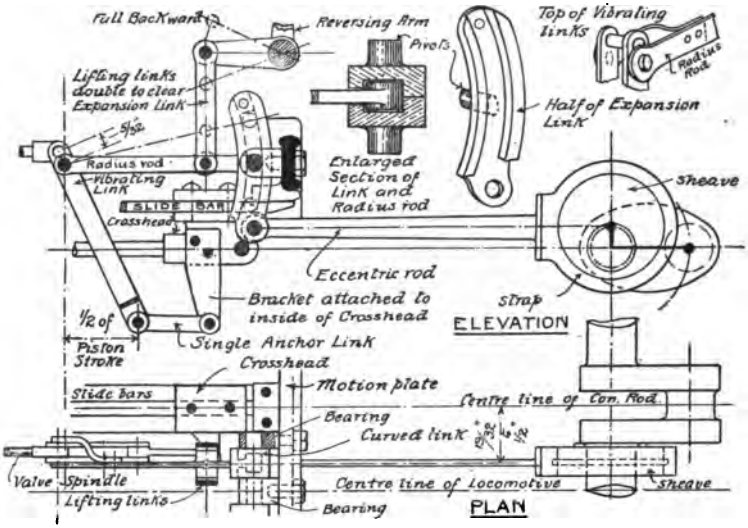


Fig. 178.—WALSCHAERT'S VALVE GEAR ARRANGED FOR A ¾-IN. SCALE INSIDE CYLINDER LOCOMOTIVE.

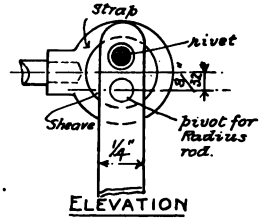


Fig. 179.

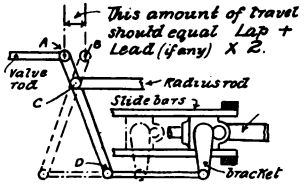


Fig. 180.—SETTING OUT WALSCHAERT'S GEAR.

pin lever C directly on to the connecting rod, but they will not proceed far without finding out the necessity for these levers. Their function is to correct the irregular movement of point *d*. due to the angularity of lever C.

To give the reader an idea of the usual proportions, the writer cannot do better than to put them in tabular form in terms

of connecting rod length, the length of this feature being $3\frac{3}{8}$ times the stroke of the piston :—

Point x to CP = $\frac{3}{5}$ of length of connecting rod.
Lever B = $\frac{5}{21}$ „ „
Lever A = $\frac{1}{2}$ „ „
(*May be varied to suit fixing at S.*)
Lever C (from y to d) = $\frac{5}{18}$ of length of connecting rod.
Point r to y = $\frac{5}{8}$ „ correcting link (B).
Point d to z varies according to lap and lead of valve (see fig. 180).
Distance Q = $\frac{4}{17}$ of length of connecting rod.
Radius of curved slide = length of rod R L.

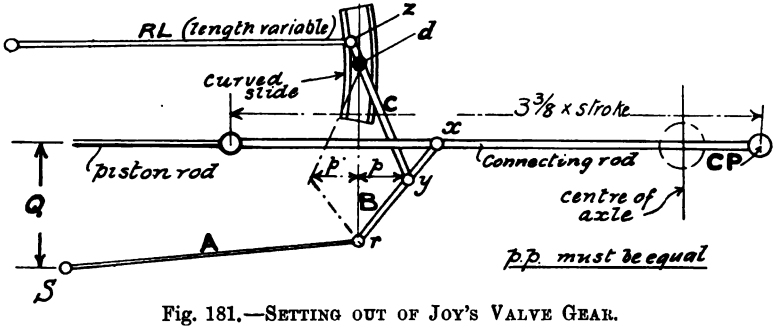


Fig. 181.—Setting out of Joy's Valve Gear.

Although the foregoing lengthy remarks on the subject of valve gearing have at times unavoidably encroached upon the practical side of the work, the following chapter will be devoted to specific arrangements, and will include drawings of valve motions which have been found to work satisfactorily in model locomotive engines to which they have been fitted.

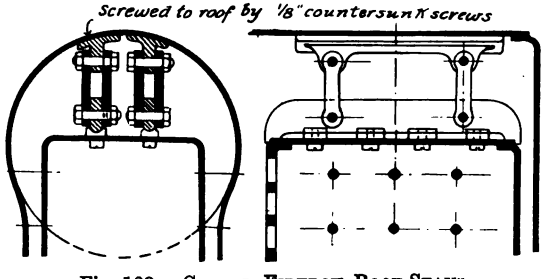


Fig. 182.—Girder Firebox Roof-Stays.

CHAPTER IX.

Motion Details.

The motion work of an inside-cylinder locomotive having the valves between the cylinders—an arrangement common in this country—requires a very great amount of skill and care even in the case of a large model, and it will not be found possible to obtain sufficient room for really sound *working model* construction in models smaller than $\frac{3}{4}$-in. scale, as will be seen from a glance at fig. 183, unless the gauge of the railway is widened. This drawing is especially arranged for the 'Dunalastair' Caledonian Railway model (Plate VII.), and in its details closely follows the prototype.

The motion plate carries the slide bars and forms a guide for the circular intermediate valve spindles. The weigh-bar shaft is supported by two plummer blocks attached to the frame. The reversing arm of this shaft is cranked to allow of the reversing rod being quite straight and clearing the side of the firebox as it passes to the cab (see fig. 186).

Owing to the restriction in the width of the space available for the machinery, which is felt mostly at the motion plate, the link motion must be of slight proportions, and it will be noticed that the lifting (or suspension) links are provided with lugs to prevent the parts jamming each other when the engine is moving. The eccentric rods are quite straight, the necessary set-over being obtained by the forked ends of the rods, which, by the way, are separate pieces riveted on.

The intermediate spindle provides for the further setting-in of the motion to the centre line of the valve spindles, and may be

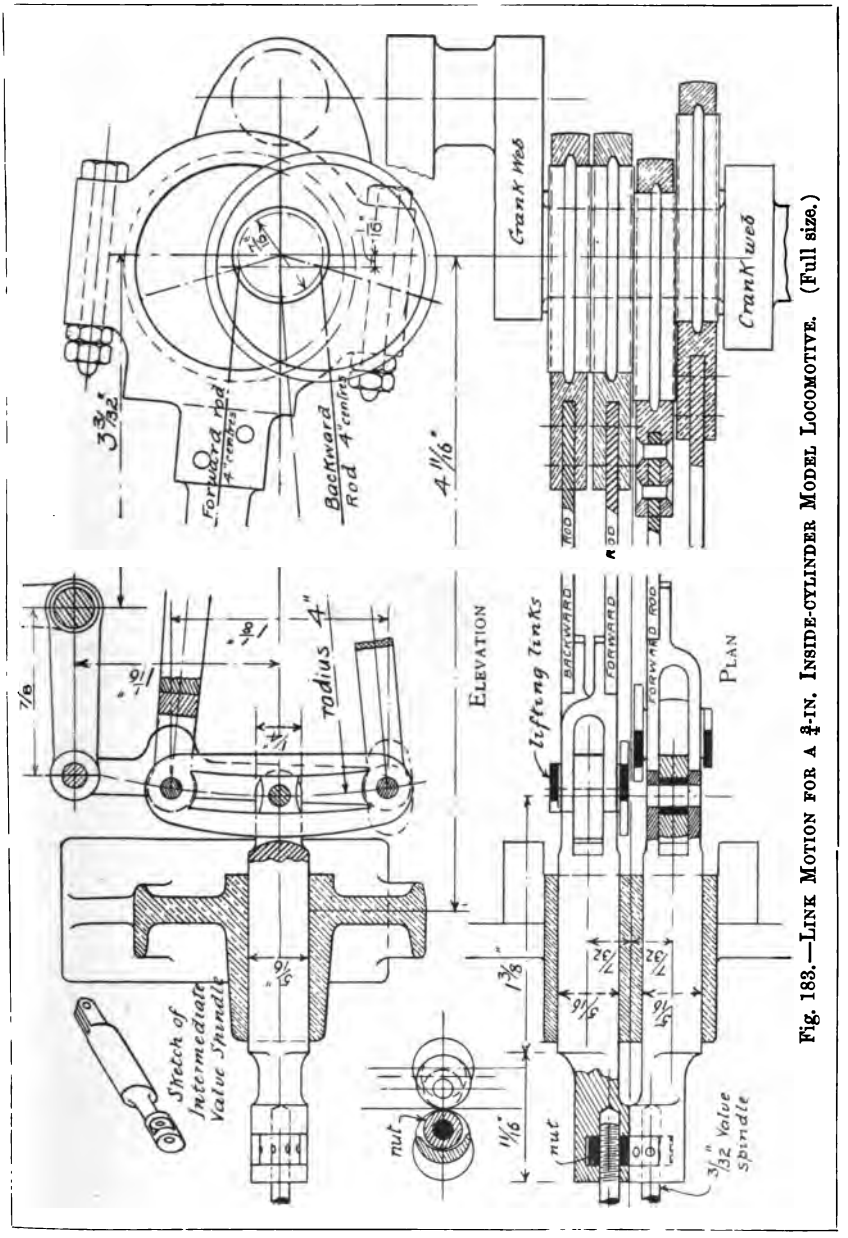


Fig. 183.—Link Motion for a 3-in. Inside-cylinder Model Locomotive. (Full size.)

made by turning up a piece of steel from three centres. The drawing (fig. 183) shows also an ingenious method of arranging the valve spindle adjustments, it not being possible to accomplish

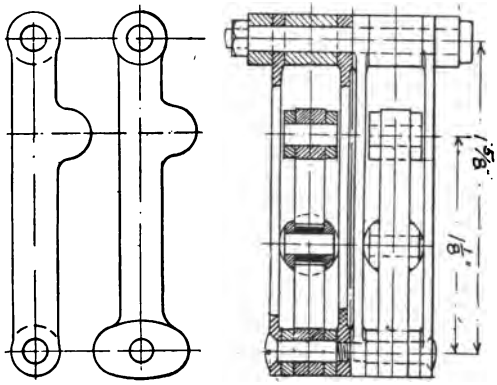


Fig. 184.—Lifting Links.

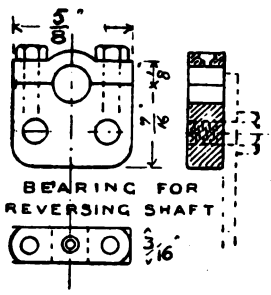


Fig. 185.

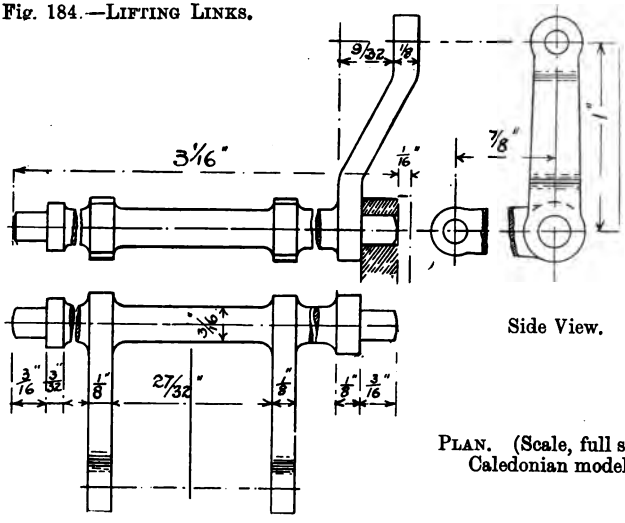


Fig. 186.—Reversing or 'Weigh-bar' Shaft.

this in the valve chest, the buckle of the valve being permanently fixed to the valve spindle. This method was devised by Mr. W. H. Dearden, the builder of a very fine model Caledonian express locomotive, shown in the photograph on p. 265.. The intermediate spindle is recessed to take a circular adjusting

nut which has several small 'tommy' holes drilled in its periphery.

More room can be obtained for the valve motion of an inside-cylindered locomotive engine by the use of one or two bars instead of four, and also by employing outside frames only, the cylinder centres in the latter instance being placed at a greater distance apart.

Under any circumstances valve setting will be difficult, and to overcome this the motion shown to a scale of half full-size in Plate I. was designed as one of the best arrangements for the 2-in. scale model engine depicted in the frontispiece to this volume; a reliable, simply-constructed locomotive capable of hard work without constant failure being the desideratum.

The gear has, up to the time of writing, given every satisfaction, and the engine may be run well linked up, retaining a good clear beat, with a very dry exhaust.[1]

The design of cylinders used is that described on page 110 with the valves on the outside, the steam-chest door opening corresponding to a similar opening in main frames, so that the valves may be inspected without removing any of the motion or disturbing any part of the engine, excepting perhaps the front-coupled wheels and the footplates.

The eccentric rods are long; indeed the whole valve gear is in all its dimensions much larger and heavier than a 'scale reduction' of any existing locomotive would provide. It is not much use increasing the length of the curved links above the ordinary proportions without doing the same thing to the eccentric rods, and to allow these to be of the maximum length the motion plate is of unusual design (see fig. 208, p. 173).

The weigh bar is $\frac{11}{16}$ in. diameter, and rests on two plummer blocks (with caps) fixed to the main frames, and as the reversing rod and cylinder centres are inclined in opposite directions, the reversing and the lifting arms of the weigh shaft take up positions at an acute angle with each other.

The lifting arms have bosses at each end and are pinned to the weigh shaft with taper pins. The pins attaching the eccentric rods and curved links and the lifting levers and links are of hard

[1] This is due in some degree to the efficient superheater employed.

rolled brass, rod material was adopted to save case-hardening and grinding, and to avoid the use of similar materials of the same hardness wearing upon each other. The renewal of the brass pins is little trouble, and no wear on the steel parts is probable; thus any subsequent reamering-out of the holes will be saved. The dies are of gun-metal, and the intermediate valve spindles of tool steel.

Builders of large engines such as the one now under consideration will often find it advantageous in the matter of lining-up, to arrange the intermediate valve-spindle guide quite separate from the motion plate as shown in fig. 187.

The eccentric sheaves are large, and are provided with a central

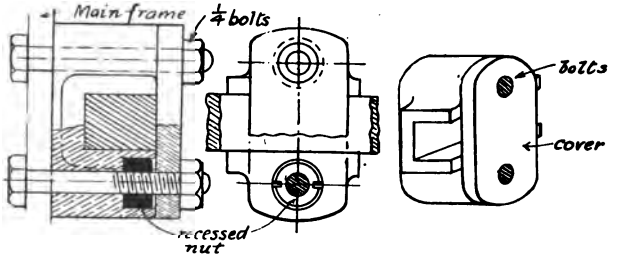


Fig. 187.—Separate Guides for Intermediate Valve Spindles. (Half size for 2-in. scale locomotive.)

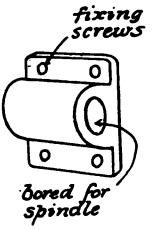


Fig. 188.—Separate Guide for Small Locomotives.

rib. This saves space and enables the provision of larger wearing surfaces. The sheaves are cast iron and the straps of best engineering gun-metal (see fig. 199, page 169).

As this engine had to be completed in a great hurry, most of the parts of the motion are made of stock bar and rod material with all bosses, lugs, etc., brazed on. The forks of the eccentric rods are formed by riveting and brazing on separate pieces as shown in the detail drawing.

To alter the position of the valve with relation to the spindle, the vertical pin in the intermediate valve spindle, which engages a groove in the valve spindle, prevents any end movement, allowing it to be rotated only, and to effect the adjustment the two lock-nutted set-screws should be slackened, and the nut on the spindle turned with the spanner. This screws or unscrews the valve spindle in the buckle, the tapped part of which is made as long

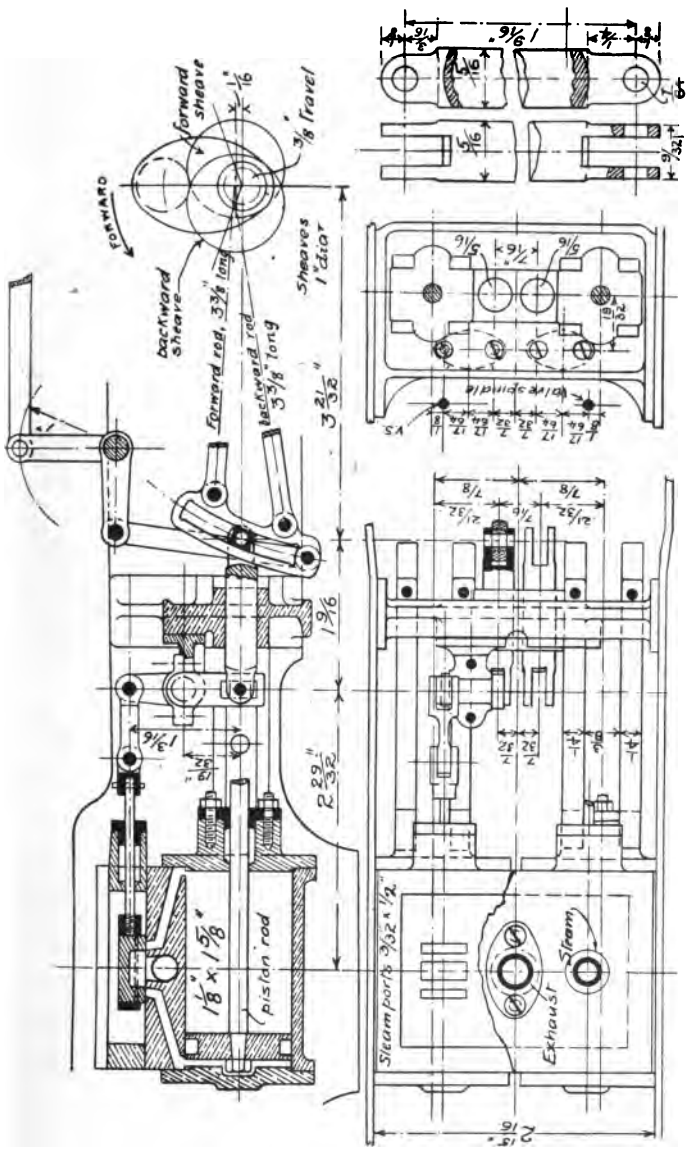


Fig. 189.—General Arrangement of Valve Motion for ¾-in. Scale Locomotive with Valves on Top of the Cylinders. (Scale, half size.)

as possible. To lock the spindles the two set-screws should be tightened up.

This design of motion is very suitable for engines of 1 to 1½-in. scales also, and within limits can be scaled down to suit the size of engine being built. Round webs for the crank axle are shown. However, these can be modified to save expense in forging (see fig. 121). The crank pins in a square-webbed axle may be made ⅞ in. in length instead of 1 in., and the eighth of an inch gained may be added to the thickness of the webs.

A large diameter of cylinders, inside the frames, generally renders the placing of the valve chest either above or below the cylinders inevitable. Where the eccentrics are placed between the crank webs, and the centre line of the valve motion coincides with

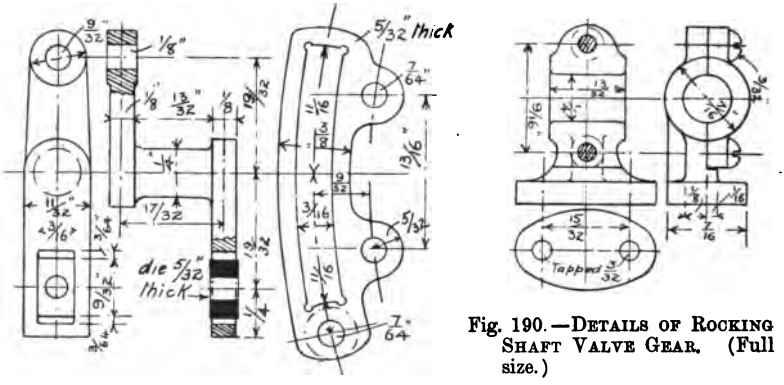


Fig. 190.—Details of Rocking Shaft Valve Gear. (Full size.)

that of the cylinders, a rocking shaft is required to transmit the motion of the intermediate or guide spindle to the valves. Fig. 189 shows a fully-worked-out example figure for a ¾-in. scale model. It will be noted that the eccentric rods being short, they are pinned to the expansion links behind the slot, and the eccentric sheaves, because of the rocking shaft changing the direction of the valve movements, are placed 180° from the usual position. Fig. 189 is a half full-size general arrangement, and includes the guide spindle shown full size. Fig. 190 comprises full-size drawings of link, rocking shaft and bracket.

A model locomotive to a scale of ¾ in. to the foot with 1½-in. cylinders should prove a powerful engine, and to ensure success a

large boiler, six coupled wheels and superheating would appear essential.

As there are many possible combinations of locomotive motion arrangements, the setting out for specific types and sizes will be left to the ingenuity of the reader, and the remaining part of this chapter devoted to the consideration of the component parts under separate headings.

Eccentric Sheaves and Straps.

Perhaps the most simple kind of strap and sheave is that possible in small engines having 'slip eccentric' valve gears.

The straps in such models may be solid, cast in gun-metal, and may work upon sheaves of cast or wrought iron having no fixing boss whatever (see fig. 192), the stop collar preventing lateral

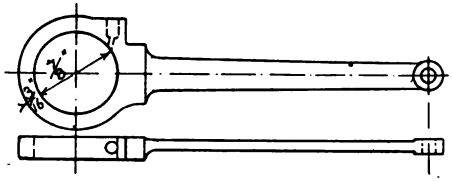


Fig. 191.—Simple Strap and Rod for ⅝-in. Scale Locomotive.

Fig. 192.—Sheave.

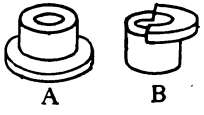


Fig. 193.—Stop Collar.

movement in one direction and the axlebox or crank web in the other (see designs on Plates II., III., and IV.). The pin which is fixed in the sheave should be so placed that the stop collar on the axle holds the eccentric in the respective backward and forward positions, these positions being exactly the same in relation to the crank pin as those of the backward and forward sheaves in a link-motion engine, and are determined in a similar manner (see fig. 174, page 149).

The writer, when adopting this kind of valve gear, generally specifies that the stop collar shall first be made as shown at A in fig. 193, and then have the larger diameter, or flange, cut exactly in half as shown at B.

Where an angular advance of the eccentric is necessary, a pin of a certain diameter is chosen. and is placed at such a distance from the centre of the axle as illustrated in fig. 195 that when engaging the stop collar the eccentric is advanced, in relation to

the crank pin, to the required degree. This illustration demonstrates that for an advance of $\frac{1}{32}$ in. the $\frac{1}{8}$-in. pin must be $\frac{3}{8}$ in. from the axle centre. If on the completion of the model it is found that less advance is advisable, then the pin may be filed away until the best results are obtained, but with careful work-

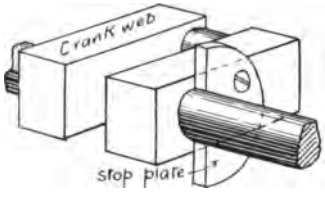


Fig. 194.—STOP COLLAR FOR INSIDE-CYLINDER LOCOMOTIVE WITH DIRECT MOTION.

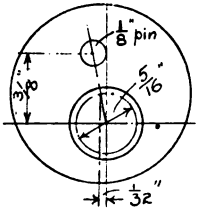


Fig. 195.—SHEAVE FOR $\frac{3}{4}$-IN. SCALE ENGINE. (Plate IV.)

manship and design no such an adjustment should be found necessary—at least when the engine is quite new.

By arranging the pin in the centre line of the eccentric, the valves are very easily set by fixing the flat face of the stop collar at right angles to the crank pin and adjusting the valve on the spindle to give an equal port opening on either side.

Very often, with inside-cylinder engines especially, the pro-

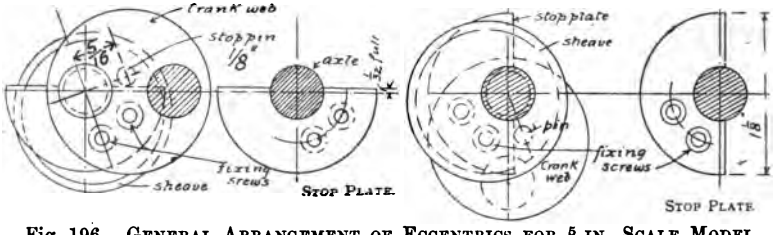


Fig. 196.—GENERAL ARRANGEMENT OF ECCENTRICS FOR $\frac{3}{4}$-IN. SCALE MODEL (Plate III.). (Views taken looking from the left-hand end of the crank axle.)

vision of a separate stop collar is impossible owing to lack of space, and a plate attached to a crank web has to be substituted. This may be arranged as shown on the sketch, fig. 194. Where a rocking shaft and inside cylinders are employed, the pin in the eccentric must be placed in a position 90° behind the centre line of its greatest eccentricity, and the stop plate shifted through an arc of similar degree, owing to the practical consideration of fixing the plate to the crank webs (see fig. 196).

The accompanying photograph shows this arrangement in actual fact, and represents the wheels, crank-axle eccentrics, straps and connecting rods for a design, much the same as that given on Plate III., a rocking shaft being used to transmit the motion to the valves, which are in the design mentioned placed above the cylinders.

Eccentric sheaves may be made with a central rib instead of

Fig. 197.—Wheels, Axle and Motion for a ¾-in. Scale Model Tank Locomotive.

outer flanges, as shown on the accompanying detail drawing of the sheaves, straps, and rods for a 2-in. scale tank engine (Plate I.). The sheaves are fixed by a single ¼-in. set-screw with lock nut placed in the cored-out spaces in the sheave.

The straps are of gun-metal, and have a slot milled out in the end to take the rod, which is riveted in place with two brass pins, or countersunk screws, riveted over.

Fig. 198 shows the straps for the ¾-in. scale 'Caledonian' locomotive as designed by Mr. E. L. Pearce. The sheaves are provided with two outside flanges, but sufficient width of strap for the

secure connection of the eccentric rods is obtained by allowing the straps to partly extend over the flanges. The length of rod is adjustable; however, the writer would advise a permanent fixing after the dead length, according to the drawing, has been arrived at.

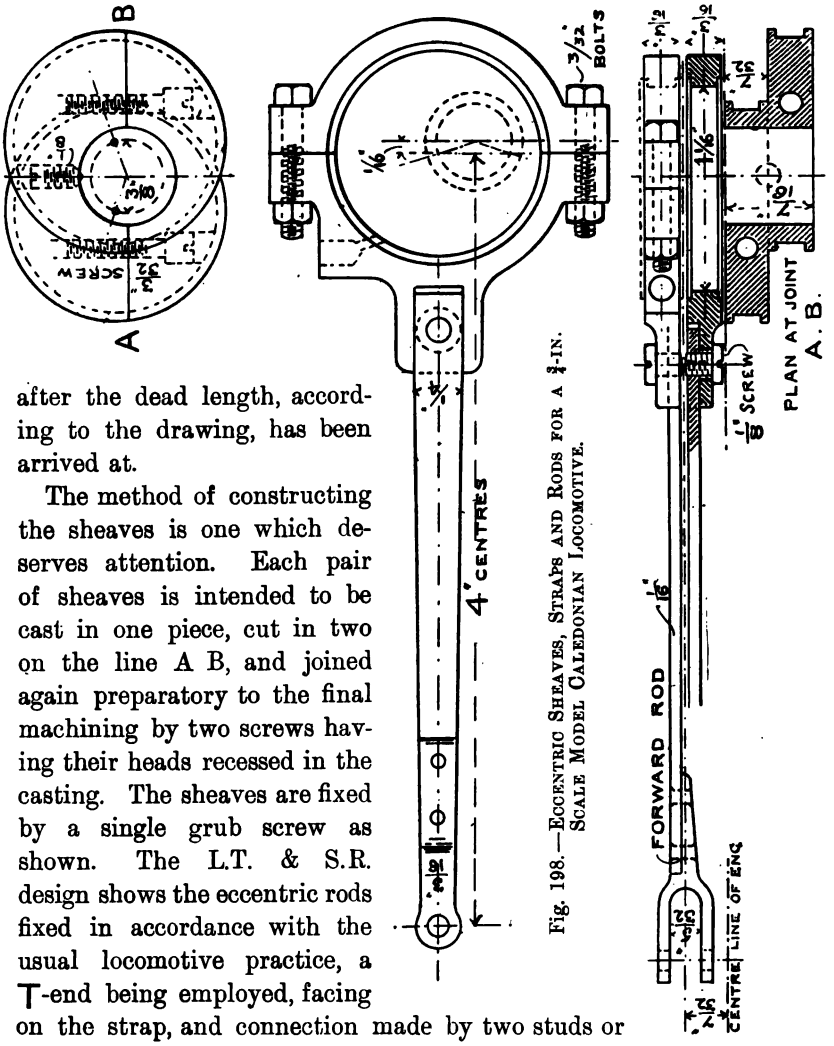


Fig. 198.—Eccentric Sheaves, Straps and Rods for a ¾-in. Scale Model Caledonian Locomotive.

The method of constructing the sheaves is one which deserves attention. Each pair of sheaves is intended to be cast in one piece, cut in two on the line A B, and joined again preparatory to the final machining by two screws having their heads recessed in the casting. The sheaves are fixed by a single grub screw as shown. The L.T. & S.R. design shows the eccentric rods fixed in accordance with the usual locomotive practice, a T-end being employed, facing on the strap, and connection made by two studs or screws.

Instead of a forked end to the rod the links are attached to a plain eye, which should be case-hardened. Owing to there being

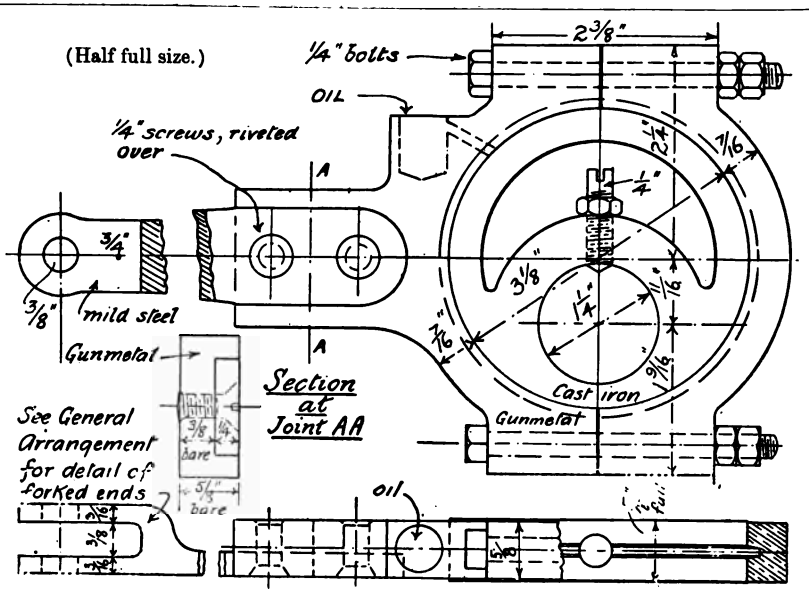
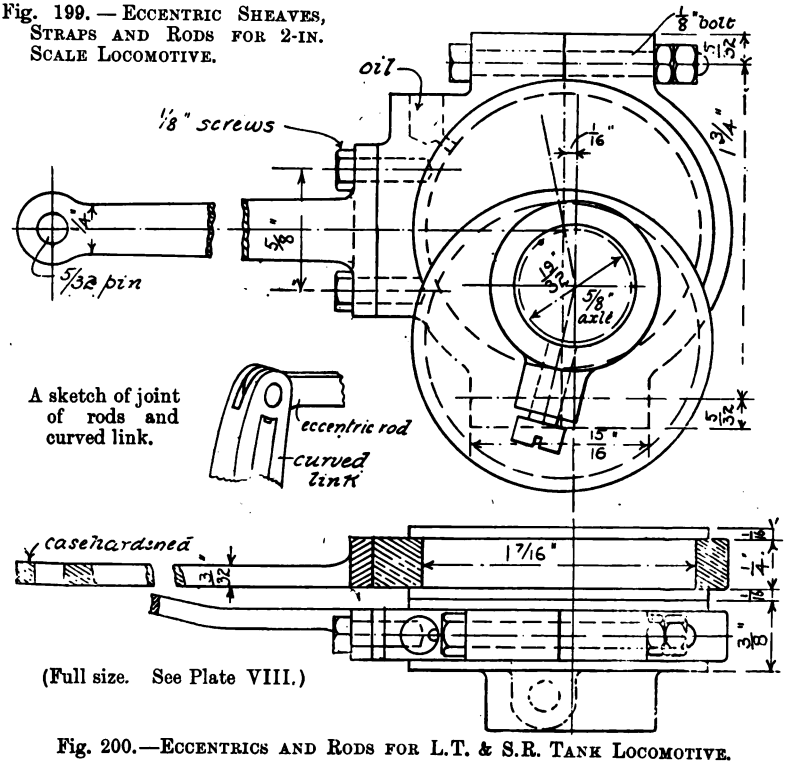


Fig. 199. — Eccentric Sheaves, Straps and Rods for 2-in. Scale Locomotive.



(Full size. See Plate VIII.)

Fig. 200.—Eccentrics and Rods for L.T. & S.R. Tank Locomotive.

plenty of room laterally, the straps are not recessed to cover the two flanges of the sheaves as in the previous example. A thicker curved link is required where a forked end is not used, and this to some extent increases the difficulties of making the link.

The photograph of the valve motion of a small model shows another method of making the eccentric straps, viz., out of steel-plate in the same form as shown in fig. 191 (page 165), and without any means of adjustment. It is doubtful whether the saving of splitting the straps is not counterbalanced by the fitting of the extra plates to the single-flanged sheaves employed in this example.

This photograph is really inserted to warn the reader against securing the rods to the curved link by a screw on one side of the link, this screw working a plain hole in the rod. As a certain amount of play is necessary between the parts, link motion built up in this manner will be found to be very liable to twisting strains, and soon become much out of line in its movements. The weigh-bar shaft is in this case supported on two bearings attached to the footplates, and a single arm is employed for lifting the links. This is a very good method in small engines, but the pins and the bearings in all cases should be as long as possible.

Valve Spindle Crossheads.

The details of the motion for the 2-in. scale design given on Plate I. depict a very good method of attaching the intermediate spindle to the valve spindle, by which the adjustment of the position of the valve on the spindle is rendered quite a simple matter. A simpler form, suitable for a smaller engine which does not employ a separate guide spindle, is shown in fig. 202, the one set-screw working in the grooved rod and the other locking it in position when the correct setting has been accomplished.

The photograph last referred to illustrates another arrangement by which a set-screw locks the valve spindle in any position to which it may be moved, fig. 203 being a modification of the same attachment designed for an inside-cylinder engine of the Caledonian type. Fig. 205 is a further method of attaining the same object.

It goes without saying that the screw adjustments are prefer-

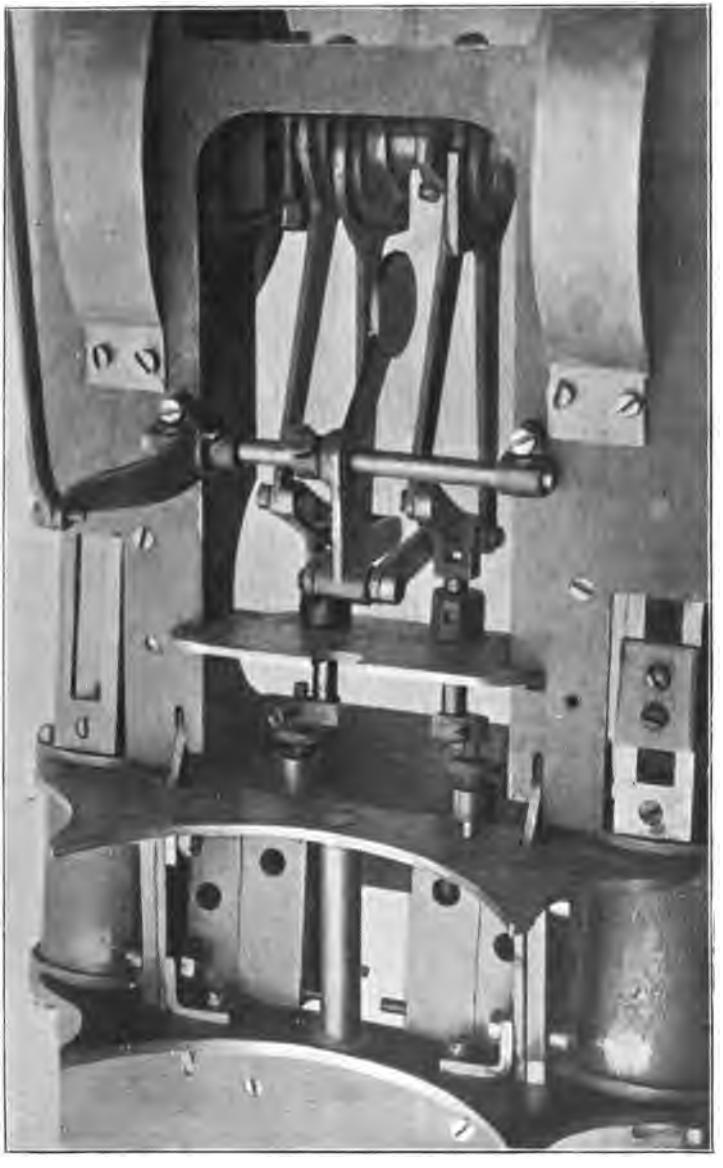


Fig. 201.—Valve Motion for a 4-in. Scale Model, showing also Building up of Saddle, Crossheads, Slide-bars, etc.

able to any other, as small movements at a time are possible and a higher degree of accuracy of setting readily obtainable.

For the 1-in. scale L.T. & S.R. design on Plate VIII., two methods are equally to be recommended. The device illustrated on the general arrangements requires the cutting of a right-hand and left-hand screw thread of fine pitch in the crosshead end and the valve spindle end of the intermediate or guide spindle. The crossheads and valve spindles are respectively screwed with right- and left-hand threads and have locking nuts, and the guide spindle is filed

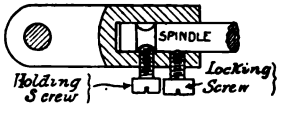


Fig. 202.

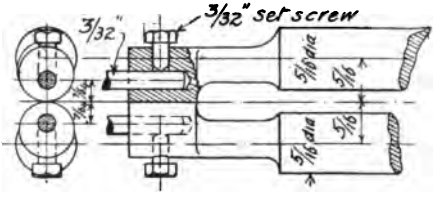


Fig. 203.

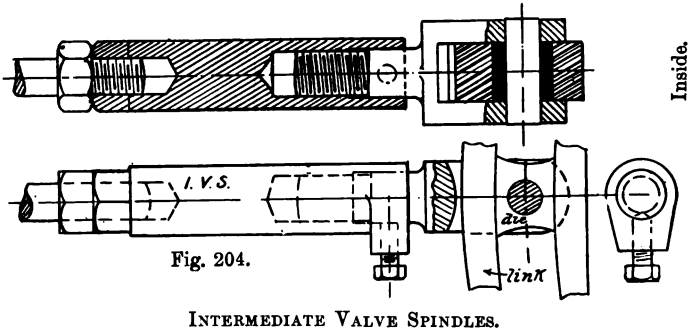


Fig. 204.

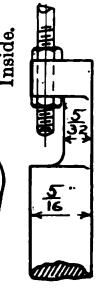


Fig. 205.

INTERMEDIATE VALVE SPINDLES.

to a hexagon shape at its forward extremity to take a spanner. To adjust the valve on the spindle, the buckle being permanently fixed, the aforesaid locking nuts should be slackened, and the intermediate valve spindle turned round one way or the other, according to whether it is required to lengthen or reduce the distance between the centre of the die of the curved link and the centre of the valve, the locking nuts making all fast after the setting operations. The detail herewith (fig. 204) is an embellishment of the idea, the object being to strengthen the joint between the guide spindle and the crosshead, and to avoid the use of right- and left-handed threads. The shank of the crosshead should be

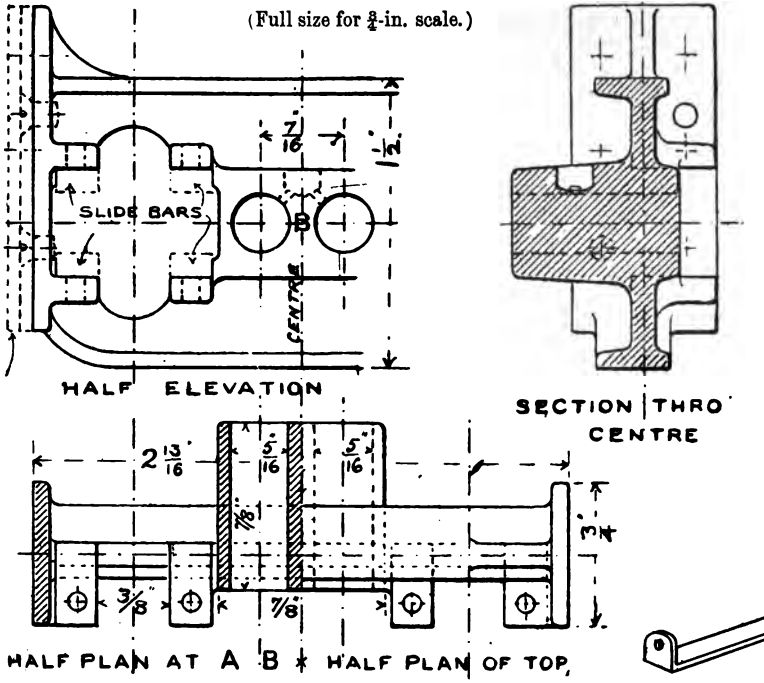


Fig. 206.—Typical Model Locomotive Motion Plates.

Fig. 207.—Simple Motion Plate.

Fig. 208.

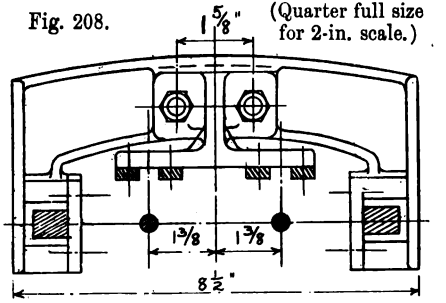


Fig. 209.

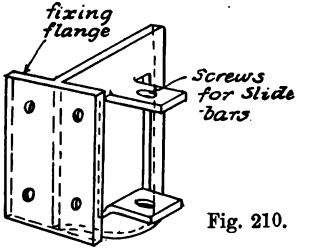


Fig. 210.

without a thread for some distance, and exactly fit a plain hole in the guide spindle, the hole lower down being tapped $\frac{1}{4}$ Whitworth. The valve spindle being $\frac{3}{16}$ in. diameter, may be tapped No. 2 B.A. The difference of the pitches of these threads will create a difference in the distances between the centre of die and valve, if the intermediate spindle is rotated, the arrangement being capable of very fine adjustment indeed. The lock nut on the valve spindle would alone securely prevent the intermediate guide spindle from revolving after the setting had been accomplished, but as an additional safeguard a set-screw is shown fitted to the crosshead end of the guide spindle.

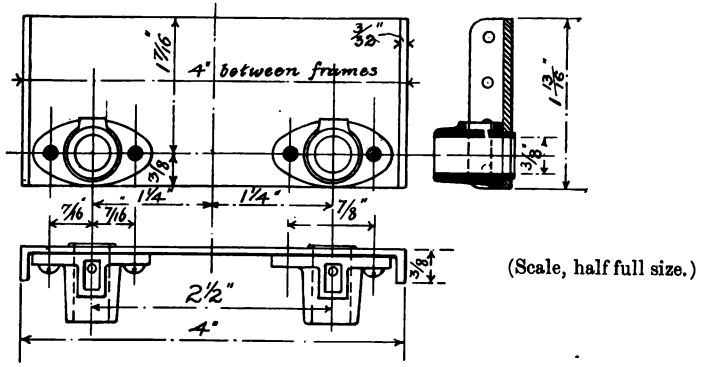
Motion Plates.

The function of the motion plate is to support the slide bars, valve guide spindle, and other parts of the motion of a locomotive engine. One of the simplest form consists of a plain bar stretching transversely from frame to frame, and may be made as shown in fig. 207.

In more elaborate engines with inside cylinders, the accompanying illustration (fig. 206), which depicts the motion plate for the model Caledonian locomotive (Plate VII.), will give an idea of the sort of casting that is required where four slide bars for each cylinder are to be supported and the valves are situated between the cylinders.

Fig. 208 is a detail of the motion plate for the 2-in. scale engine already referred to in this chapter, and clearly shows the extension carrying the slide bars, these and the intermediate valve spindles being cross-hatched as if in section.

For outside-cylinder engines it is only necessary to support the valve spindles, and the motion plate, apart from this, is employed only as a means of strengthening the main frames. Fig. 211 shows the motion plate for the model 1-in. scale L.T. & S.R. engine (Plate VIII.), the valve spindle guides being separate castings and the motion plate made out of sheet material. Fig. 212 is another form suitable for a $\frac{3}{4}$-in. scale, using a Bissel bogie or single truck leading and outside cylinders. The plate, with guides and brackets, is in one casting.



(Scale, half full size.)

Fig. 211.—Motion Plate for 1-in. Scale L.T. & S.R. Locomotive.

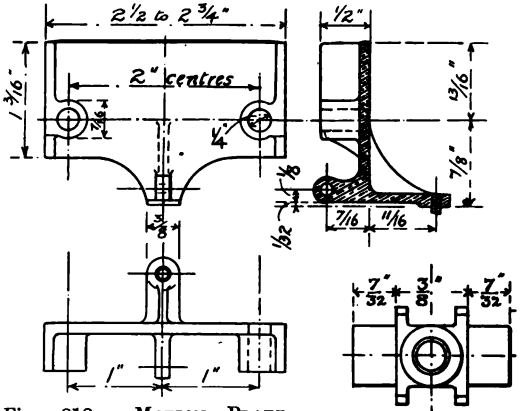


Fig. 212. — Motion Plate for ¾-in. Scale Outside-cylinder Model.

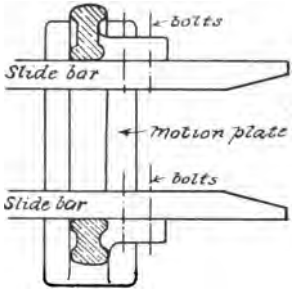


Fig. 214.—Double Slide Bar supported near Centre.

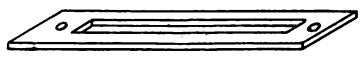


Fig. 213.—Slotted Slide Bar.

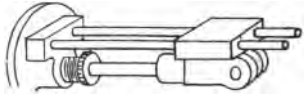
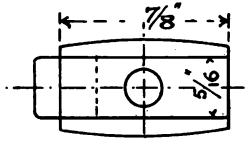


Fig. 215.—Simple Slide Bar and Crosshead.



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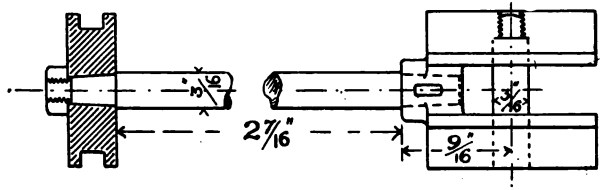


Fig. 216.—Crosshead for ¾-in. Scale Caledonian Rly. Loco.

Outside-cylinder engines are as a rule provided with two motion plates, one outside and one inside, although, as has been hinted, the latter can be dispensed with, and the valve spindle supported either by a bracket (fig. 188) from the frames, or by the use of a tailed spindle and dummy gland.

The outside motion plate should for a two-bar suspension be arranged something like in the accompanying sketch (fig. 210), this example being intended for manufacture from plate material.

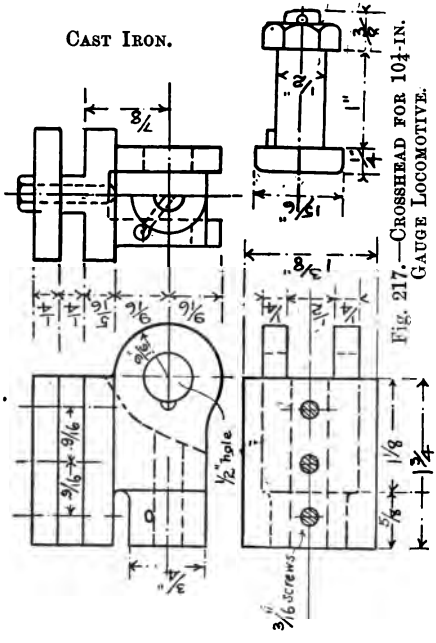


Fig. 217.—CROSSHEAD FOR 10½-IN. GAUGE LOCOMOTIVE.

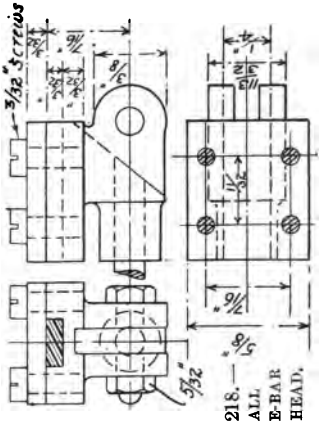


Fig. 218.—SMALL SINGLE-BAR CROSSHEAD.

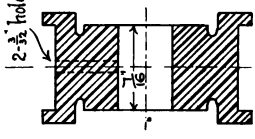


Fig. 219.

The writer, in single-bar outside-cylinder engines, generally uses a bracket which serves both to support the footplates and the single slide-bar; the bracket may either be a casting or bent up out of bar material (see fig. 209).

CROSSHEADS AND SLIDE BARS.

The design of crossheads depends almost entirely upon the arrangement and shape of the slide bars, and also the form of the little end of the connecting rods. Where the ordinary single bar placed on

top of the piston rod is used, the crosshead may to a large extent follow the prototype, that is, in engines of 1-in. scale and upwards (see fig. 220). It will be found that in small model locomotives employing a single bar, that if the bar is kept to scale the proportions of the crosshead will become rather clumsy, and therefore the former will have to be made smaller in sectional area, as shown in fig. 218.

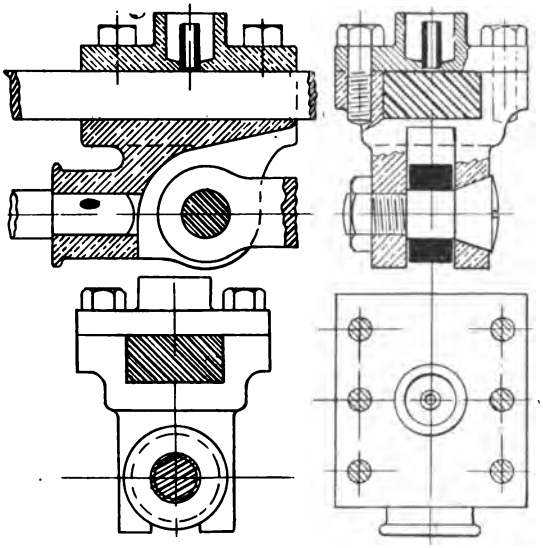


Fig. 220.—Crosshead for 1-in. Scale L.T.S.R. Model.

A type of crosshead which, as far as the writer is aware, is not used in locomotive work, but gets over this difficulty, is illustrated in figs. 217 and 221. Either a single flat bar with the centre milled out, or, in the case of a large model, two separate bars, may be employed. The forked portions of over-bar crossheads—where the connecting rod little end is not forked but attached by a plain eye and pin—will be found to be more easily filed or machined out if they project slightly from the body of the cross-

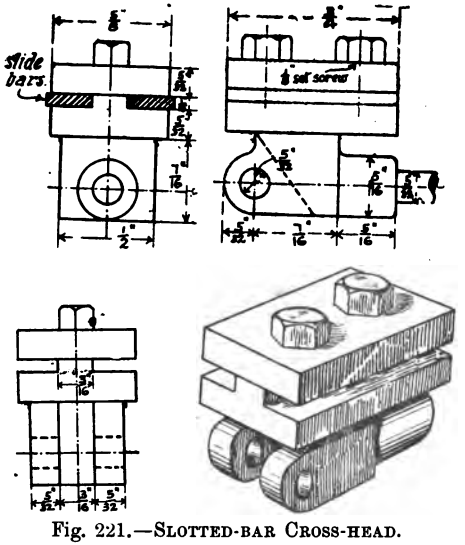


Fig. 221.—Slotted-bar Cross-head.

head as shown in figs. 217 and 218. A very simple model of a 'single-bar' crosshead may be made by adopting the device shown in fig. 215, supports for the end of the rods forming the slide bar not being absolutely necessary in tiny engines.

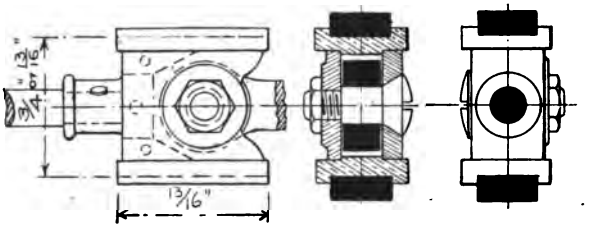


Fig. 222.—A ¾-in. Scale Great Northern Railway Crosshead.

The sketches, figs. 219, 222 and 223, illustrate two types of two-bar crossheads, one for where the forked little end is used and the other for eyed ends.

The G.W.R. employ the former method very extensively, and the latter is more or less a copy of the crosshead used on the G.N.R. 8 ft. singles. In the former example the gudgeon pin is fixed in the little end, and therefore oscillates in the crosshead, and in the G.N.R. example the gudgeon pin is fixed in the crosshead, being tapped into one cheek of this fitting. From a model-making point of view the adoption of the G.N.R. type of crosshead means that either the recess in the crosshead must be carefully cored out, or milled out (this, however, would not be altogether satisfactory), or the cross-head may be built up as indicated in the sketch, suitable pieces of steel being first pinned together and then brazed up as shown.

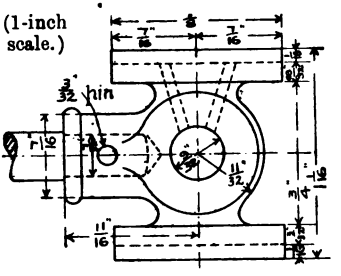


Fig. 223.—A Two-bar Crosshead.

With the two- and four-bar slide bar arrangements the motion plate need not be attached right at the back end of the bars, but may be placed nearer the centre, this method allowing of a greater length of eccentric rod and link motion of ampler dimensions.

Fig. 216 illustrates the crosshead for a ¾-in. scale model having

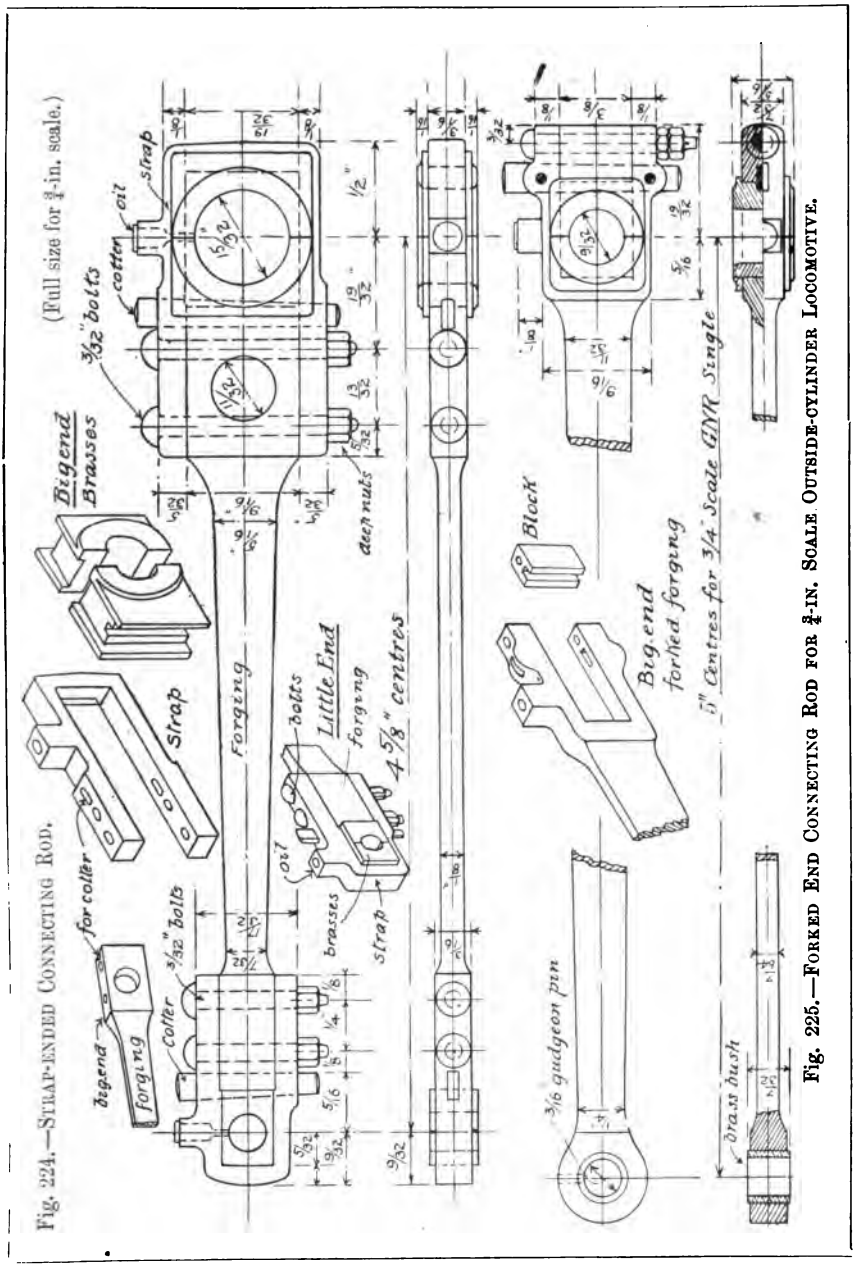


Fig. 224.—Strap-ended Connecting Rod.

Fig. 225.—Forked End Connecting Rod for ¾-in. Scale Outside-cylinder Locomotive.

four slide bars, the crossheads and slide-blocks being of one piece of metal instead of in the separate parts usual to larger practice.

CONNECTING AND COUPLING RODS.

Whilst connecting rods for working model locomotives generally resolve themselves into modifications of the marine type, a drawing of the orthodox strap-ended rod, which is almost universally used by English engineers for inside-cylinder locomotives, is illustrated herewith (see fig. 224). The connecting rod forging is lightened at the 'big end' by the circular piercing, and the

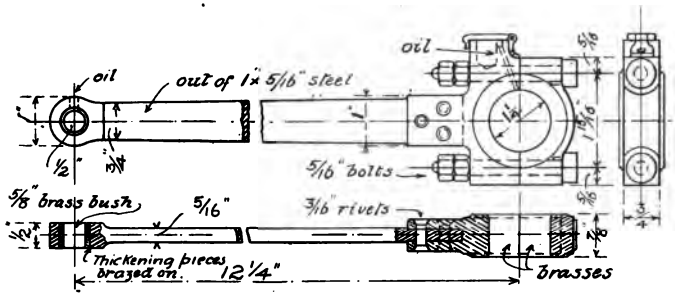


Fig. 226.—CONNECTING ROD FOR 10½-IN. GAUGE LOCOMOTIVE.

brasses are attached by a strap which contains the oil cup and holds the cotter, the strap being affixed by two well-fitting turned bolts.

The use of a cotter in a model 'big end' not being imperative, as adjustment for wear and tear is necessary only at prolonged intervals, this portion may be omitted. As no set-screws for securing the cotter are shown in fig. 224, the cotter (if used) should be of very slight taper.

On some railways a form of 'marine' big end is employed, and the modification of this making it suitable for a ¾-in. scale model is shown in fig. 228. Still simpler arrangements are illustrated in figs. 226 and 227, the latter connecting rod being designed to be a single casting in gun-metal. Phosphor bronze and German silver may be mentioned as very suitable materials for connecting rods, the former more especially for inside-cylindered engines and German silver in place of steel for outside-cylinder locomotives. The latter has the appearance of steel, and does not rust.

The same type of connecting rod was adopted for the 2-in. scale model tank locomotive previously referred to, the back half of the big end brasses containing a siphon oil cup, the rods being of steel riveted to the big end, and the little ends thickened by brazing pieces of steel on each side of the rod (see fig. 226).

For outside-cylinder engines the forked 'big end' is common, a good example being illustrated by fig. 225. A modification is shown in fig. 230, the construction of this being extremely simple and at the same time good practice, as the bush can easily be renewed when wear takes place. The bush is driven into a circular hole in the 'big end' forging and sweated if necessary, and has a square flange on the face to imitate the brasses of a proper big end. The oil cup should be wrought from the forging, and the dummy cotters and bolts may be made in a similar manner or be formed out of screws fixed in the forging.

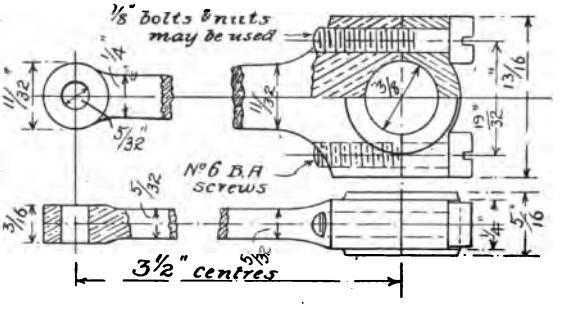


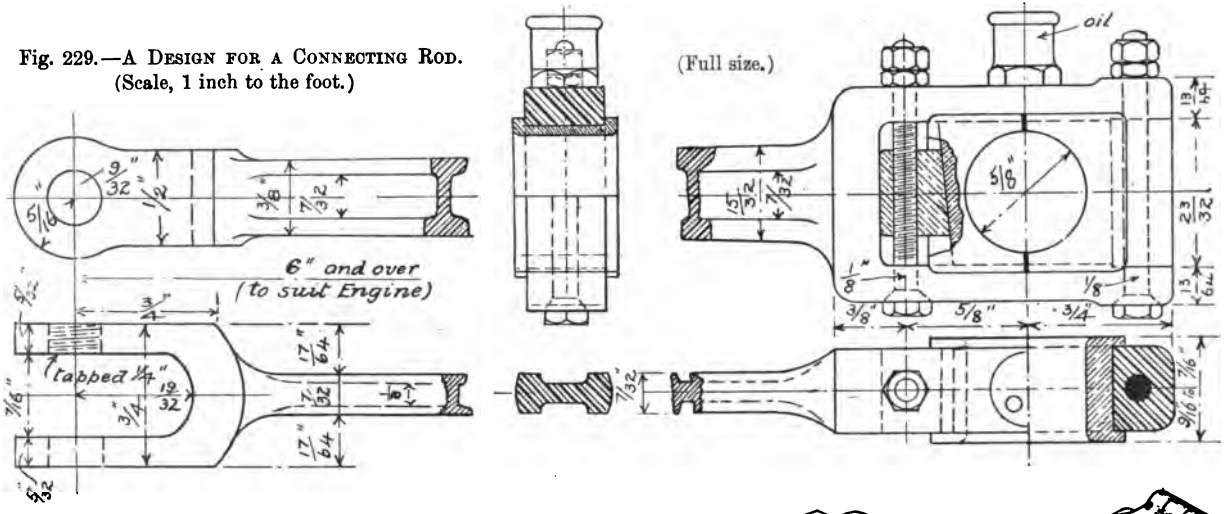
Fig. 227.—Connecting Rod for ½-in. Scale Locomotive. (Full size.)

The small ends ('little ends') of locomotive connecting rods are nowadays invariably provided with plain bushes instead of split brasses, and are not commonly forked, the G.W.R. and L. & N.W.R. being the principal users of forked little ends.

Fig. 229 illustrates a connecting rod made in this way, the gudgeon pin being fixed in and oscillating with the rod. The same drawing shows another way of adjusting the big end brasses for wear, the wedge being moved by a screwed bolt and secured by lock nuts.

In length, connecting rods should never be less than two and three-quarters to three times the stroke of the piston, and modern practice is to make them rectangular in section and more often than not, fluted. For six-coupled bogie express and 'Atlantic'

Fig. 229.—A Design for a Connecting Rod.
(Scale, 1 inch to the foot.)



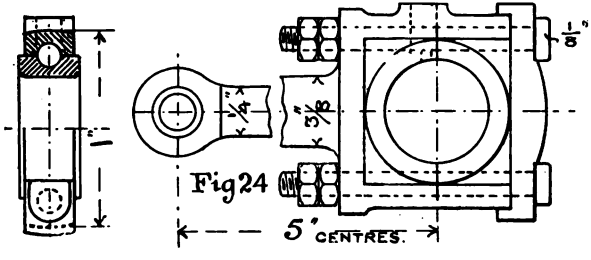


Fig. 228.—Connecting Rod for ¾-in. Scale Caledonian Locomotive.

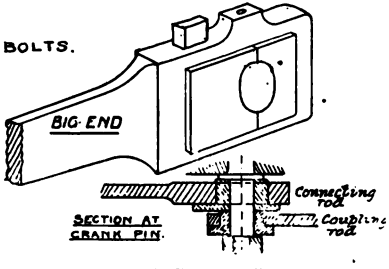


Fig. 230.—A Simple Connecting Rod 'Big End.'

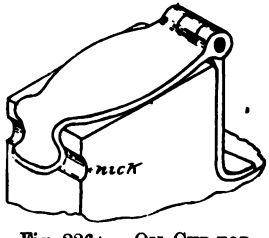


Fig. 226A.—Oil Cup for Rod shown in Fig. 226.

types of locomotives connecting rods are frequently 10 ft. in length. Other dimensions may be obtained from the examples shown, which are all drawn more or less to scale. I section are generally slightly larger in width and depth of section than plain rods, and for a given weight of metal are of course much stronger.

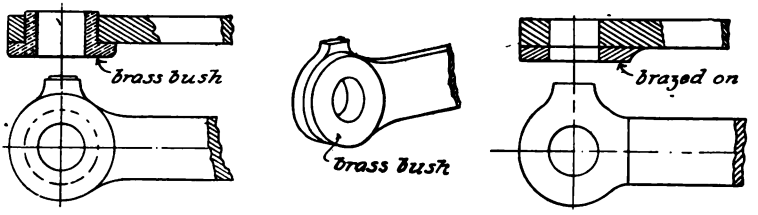


Fig. 231.—Coupling Rod Ends.

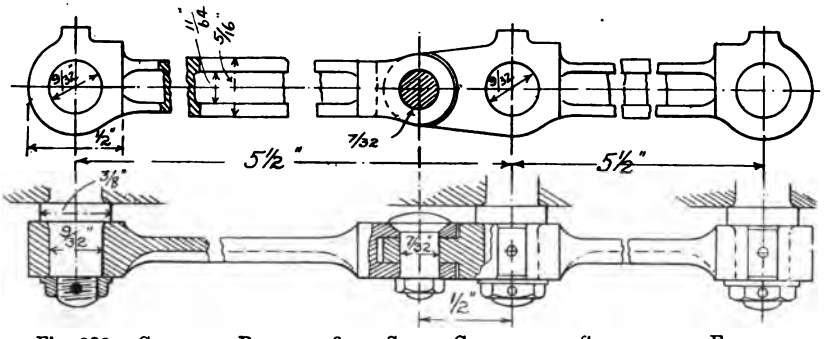


Fig. 232.—Coupling Rod for ¾-in. Scale Caledonian Six-coupled Express Locomotive.

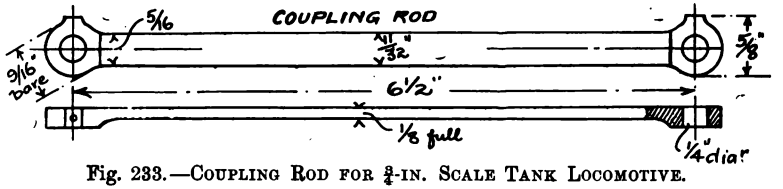


Fig. 233.—Coupling Rod for ¾-in. Scale Tank Locomotive.

Coupling rods fitted to engines having cylinders placed between the frames, are as a rule attached to crank pins which are given slightly less throw than the main crank pins, and it is now the practice to almost exclusively employ solid flushed ends instead of split brasses.

Modern engines are also generally fitted with I section rods. Figs. 233 and 232 show respectively coupling rods for a four-

coupled express and six- (or more) coupled engines. Where more than four wheels are coupled, to allow the up-and-down of the axleboxes, each section of coupling rod must be separate from the other and connected by a pivoted joint.

For small models the brass bushes and fluting may be omitted,

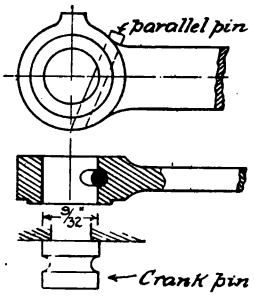


Fig. 234.—Coupling Rod End for Model G.N.R. 'Atlantic.'

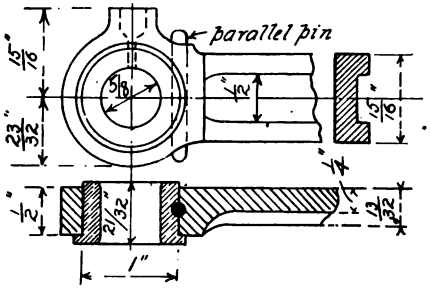


Fig. 235.—Coupling Rod End for 10¼-in. Gauge Locomotive.

and the ends case-hardened (see fig. 233). Model-makers who favour the use of plate material may use ends as shown in fig. 231.

In the model G.N.R. 'Atlantic' locomotive design (Plate V.) the forward end of the coupling rods having to be of very small width in plan, to clear the connecting rod, the construction shown in fig. 234 has been adopted, it being impossible to copy the arrangement used in the prototype. The crank pin should be hardened, and the pin which secures the rod from falling off attended to at intervals and renewed if necessary.

Fig. 235 is a detail for a coupling rod for a model 2-in. scale front-coupled tank locomotive. It has brass bushes, and fits the orthodox crank pin having an inside collar to keep the rod away from the wheel and a screwed securing collar on the outside.

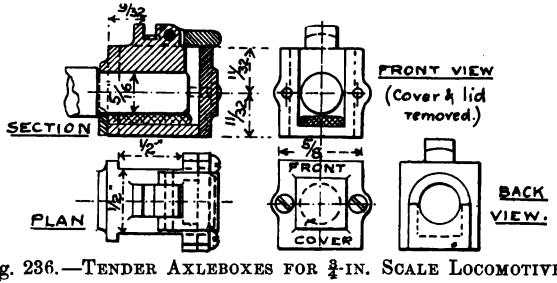


Fig. 236.—Tender Axleboxes for ¾-in. Scale Locomotive.

CHAPTER X.

Boiler Construction.

Commencing with the construction of the simplest type of boiler mentioned on page 55, Chapter IV., and premising that a piece of drawn tube is used for the barrel, only two joints, at the ends, will be required. The common method of putting the ends into these boilers, adopted in some of the cheaper all-brass models, is to be strongly condemned as unsafe. Stays are not used, and the ends are extremely narrow (see fig. 237) on the flange, and directly the solder gives way nothing can save the end from being blown out. Rivets or screws cannot be used, because of the limited width of the flanges.

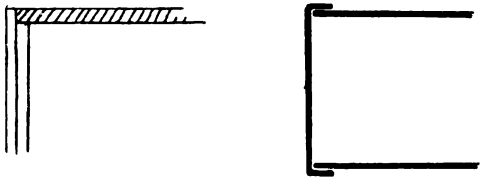
Small models of Continental make usually have the ends deeply flanged over the tube. The ends are driven on tightly and secured with solder, and although, as in the previous kind, failure would be entirely prevented by the use of a longitudinal stay, these ends seldom blow out with the moderate steam pressures employed.

The charm of the 'plain pot' boiler is large water range, its immunity from troublesome leakages—that is, where water tubes are not employed. If properly made in the manner to be described a disastrous failure should be next to impossible; the smallest generator should be capable of being worked at 100 lbs. pressure, and if made of copper and brass last for many years.

A piece of solid drawn tube should be obtained, the walls being of the correct thickness (see page 62, Chapter IV.), in any case never less than $\frac{1}{20}$ in. (No. 18 S.W.G.), and mounted in the lathe by inserting a wooden mandrel in the tube, or temporary plugs in the ends; the tube should be cut quite square.

The extremities of the tube may then be filed or turned with

knife edges as shown in the sketch, and the boiler ends turned to a diameter slightly larger than the bore of the tube. The two ends should then be fitted on to the central stay, one being permanently fixed before placing in the tube, the nut *b* being used to



Figs. 237 and 238.—Fixing Boiler Ends.

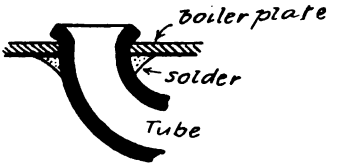


Fig. 241.—Fixing Water Tube.

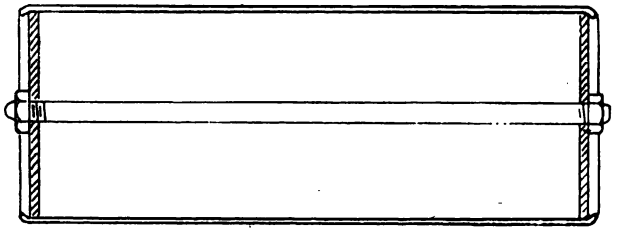


Fig. 239.—Finished Boiler with Spun-over Ends.

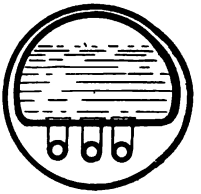


Fig. 242.—D-tube Boiler.

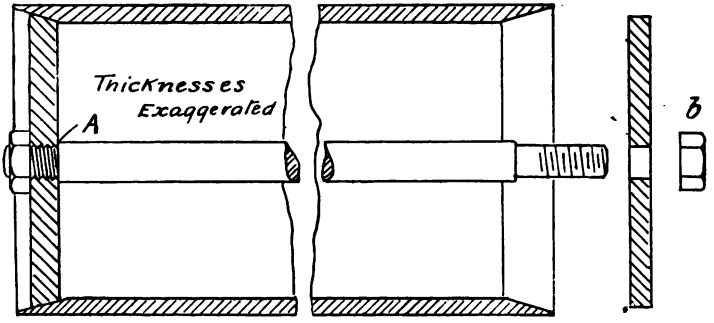


Fig 240.—Fixing Boiler Ends.

jam the ends in the barrel. The centres in the stay being preserved, the whole may be put in the lathe and the boiler barrel spun over the ends with a smooth tool. The parts should be tinned with solder, when a final sweating will result in a boiler which will never fail under ordinary usage.

Instead of making the boiler shell with knife edges, three screwed

pins may be let in a little way from the edges at each end so that they project and form a support for the boiler end during the subsequent operation of spinning over the barrel.

Where cast flanged ends are employed such as are shown in fig. 247, and the barrel is under 3 inches in diameter, no stay is necessary, and to prevent the ends from parting from the barrel rivets or screws (brass) can be used.

To determine the size of the rivets or screws securing a boiler end, the shearing strength, multiplied by at least six (factor of safety) should balance the total pressure on the ends. As an example, say the end is 3 in. diameter and the working steam pressure 50 lb. per sq. in., and taking the shearing strength of hard brass at 10,000 lb. per sq. in., then

6×50 lb. $\times$ area of boiler end = No. of rivets $\times$ shearing strength of one rivet.

$$\text{No. of rivets} = \frac{6 \times 50 \times \text{area of end}}{\text{shearing strength of one rivet.}}$$

Now the cross-sectional area of an $\frac{1}{8}$-in. brass pin is $\frac{12}{1000}$ sq. in., and therefore the force required to shear it will be $\frac{12}{1000} \times \frac{10000}{1} = 120$ lb., and the sum works out as follows:

$$\text{No. of rivets} = \frac{6 \times 50 \times 7}{120} = \frac{35}{2} = 17\tfrac{1}{2} \text{ rivets, or rivets at } \tfrac{1}{2} \text{ in. pitch.}$$

However, if the boiler can have the edges of the tube spun over the ends in the manner already described, a fewer number may be used, as the large factor of safety of 6 in this case is not needed.

Where water tubes are employed to increase the evaporative power of a boiler, the methods of fixing the tubes will have to be carefully considered. Undoubtedly the best means of putting together a water-tube boiler more especially, is to braze or silver-solder the whole of the joints. The former system of jointing consists of soldering with a species of brass solder which fuses at nearly the same temperature at which the work to be operated upon will melt. There are, however, various grades of brazing 'spelter,' but even the kind that has the lowest melting point will not prove so easy of manipulation as the amateur would wish, and therefore the next step nearer to the use of soft (or

pewter) solder is to adopt the method of jointing known as 'silver-soldering.'

Silver solder melts at an average temperature of about 1200° Fahr., 'hard' spelter fusing at about 1500°, and the joint formed, except that it can be seen against the brass or copper work upon which it is used, will be found quite as strong as the surrounding metal. This cannot be said of soft (tinman's) solder, which melts at from 360° to 500° Fahr., and which is always liable to run if the boiler is allowed to become short of water.

Silver solder is, therefore, a useful all-round material, and if facilities in the way of a sufficiently powerful blow-lamp or gas blow-pipe preclude its use on larger work, all small pipes, etc., should be so jointed.

The flux used is borax, and after soldering, the work may be cleaned by dipping a diluted solution of sulphuric acid. Whilst it is always advised to fix the water tubes of a small boiler by silver solder in preference to any other method,[1] the *ends* of a Smithie's boiler may be affixed in the way described on page 186 and in figs. 239 and 240, and soft solder used to 'sweat' the joint, the *silver-soldered work being done first.* The boiler barrel should be buried in coke to allow it to retain the heat, and the flame of the lamp should be directed toward the more massive portions of the work.

Should it not be possible to use silver solder at all, then the tubes may be burred over on the inside as shown in fig. 241 and the joint well sweated with soft solder.

A type of boiler which the writer experimented with some years ago, suitable for very small scale models in which the Smithie's boiler with its double tube is not advisable, is depicted in fig. 243. A larger water and flue space than in the kind just mentioned may be provided, and although the boiler may not be so strong and there may be greater losses by radiation, no difficulties should be occasioned in the matter of the steaming qualities of the generator if small-bore cylinders and superheating are employed.

The thickness of the shell of the boiler illustrated should be $\frac{1}{20}$ in. and the working pressure should not exceed 25 lb. The continuous crown sheet may have the water tubes silver-soldered in

[1] The joints of the water-tube boiler will always melt before a properly fitted and 'spun over' end.

after it is flanged and shaped, when the sheet may be fixed to the boiler barrel and the flanged D ends soldered in. Screws or screw pins flush on the outside should be used throughout, and where necessary holes may be made in the shell to affix these. A central vertical stay (or stays) should be employed to strengthen the crown. The safety-valve casing may be used as an extra flue or funnel, as suggested on page 240, and a flame-heated superheater tube may be very easily fitted—indeed this should not be omitted, as in very small models cylinder condensation is considerable and the boilers are frequently over-cylindered in spite of all endeavours to the contrary. As regards dimensions the drawings give all

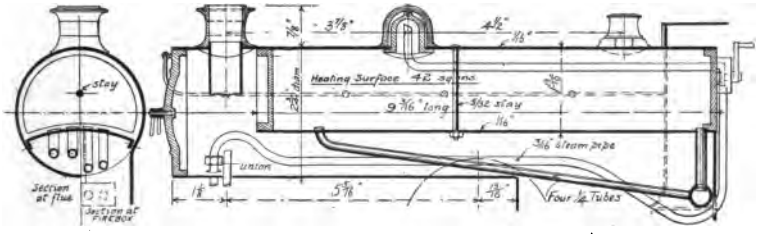


Fig. 243.—A Simple Water-tube Boiler for ½-in. Scale Model.

particulars. The modification of this design shown in fig. 242, although to some extent it will entail extra cost and labour, will in other respects make a more satisfactory job. A separate outer shell is employed, the inner shell—the boiler proper—being of ⊂ section tube. This tube *can* be obtained, but if any difficulty is encountered in procuring it, a piece of solid drawn tube may be hammered to shape on a mandrel, and the amateur coppersmith can console himself that any little irregularities in the outline and the hammer marks will be hidden by the outer shell.

A drawing embodying Mr. Smithies' design in its entirety, and also the method of fixing the ends described on page 186, is depicted in the accompanying Plate II. Its dimensions and mountings are arranged to suit a ½-in. scale model N.E.R. locomotive No. 1619.

Three ¼-in. water tubes are employed, and it will be noted that at the throat plate each of these tubes only just misses the joint of the barrel and the throat plate in the manner advised in the chapter on Boiler Design. The smokebox is formed by splitting the

outer shell at the front end (fig. 244) and fitting a cast smokebox front, which should not be permanently fixed when the engine is completed. The back of the smokebox is filled by a plate, also shown in fig. 244 (B), a flanged bottom plate (C) ensuring an air-tight smokebox. The inner barrel—the boiler proper—is attached to outer shell by a short stud fitted with a nut in the space inside the dummy dome. The regulator is a plain plug cock, and is intended to be actuated by the smokebox door handle, this having a square eye hole, the wheel locking it in position. This type of regulator has been found very convenient for tiny models, and as the type of cab used in the N.E.R. locomotives creates difficulties in the way of manipulating fittings, the heterodox method of arranging the regulator shown in this design is in some measure excusable.

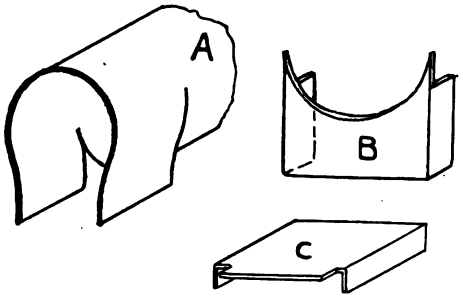


Fig. 244.

The firebox is very long, and a slot must be cut in the sides to allow the trailing axle to pass. The steam pipe also must be bent to clear the blast pipe. If a piece of tube is used for the outer shell, then the sides of the firebox will require adding to, in the methods to be shown hereafter. As the model is intended to be as nearly as possible to scale, the outer shell is $2\frac{9}{16}$-in. diameter and inner one $1\frac{3}{4}$-in.; however, in other designs of locomotives to $\frac{1}{2}$-in. scale, boilers having $2\frac{3}{4}$-in. outer and 2-in. inner barrels are obtainable.

Larger Smithie's type boilers suitable for $\frac{5}{8}$-in. scale model locomotives are illustrated in the designs described on pages 254 to 260. In the six-wheeled G.W.R. type tank locomotive a T downcomer is employed, whilst in M.R. 'compound' and the front-coupled tank locomotive designs, cast downcomers are advised.

The boiler of the front-coupled engine is the better of the two last mentioned, although the heating surface is nominally less, five water tubes being employed in place of seven in the Midland locomotive, the increased room in the firebox, the provision of a hole

in the downcomer and a corresponding opening in the backplate, smaller number of water tubes, and the slightly increased outer barrel, improving the ventilation of the fire.

It will be noticed that in the smaller designs for Smithie's type boilers the cast downcomer of square shape has been as a rule substituted for an arrangement of down tubes. The reason for this is twofold. The cast downcomer was designed by the writer as a very ready means of firmly securing to the barrel of the boiler, by rivets (or screws) and *soft* solder, a solid fitting with few joints, to provide a large body of water at the lower ends of the water tubes for ensuring a good circulation and no likelihood of dry tubes, and to allow the tubes to be easily screwed into the downcomer.

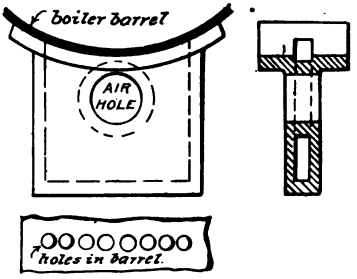


Fig. 245.—Cast Downcomer.

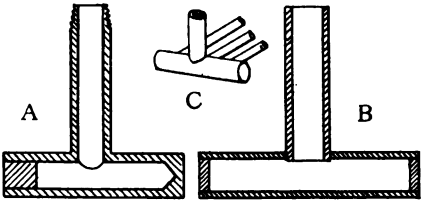


Fig. 246.—Tee Downcomer.

It has certainly accomplished these requirements in practice, but in the smaller sizes of model locomotives it is found that unless a hole is cored in the downcomers as shown on the sketch, the draught, and therefore the 'ventilation' of the fire, is considerably retarded, and steam raising without the use of auxiliary fittings or opening of the smokebox door occupies a longer time than it should. Of course the hole in the downcomer should correspond with an opening in the back plate, as already referred to, a movable door being fitted to the latter in a convenient manner.

Such a firehole and door is a simple matter with a downcomer built up of tubes, and the latter also may be made to take up less room in the firebox. An inverted T downcomer may be more easily silver-soldered into the barrel, that is, if the joints of the plugs and tubes are also silver-soldered or brazed. Otherwise, the downcomer may be screwed into the barrel with a fine thread, and

subsequently sweated with tinman's solder. A cast downcomer requires a little more skill and larger appliances to satisfactorily silver-solder or braze on to the boiler barrel, especially in the case of a $\frac{3}{4}$-in. scale model.

The value of the cast downcomer is seen in boilers for engines

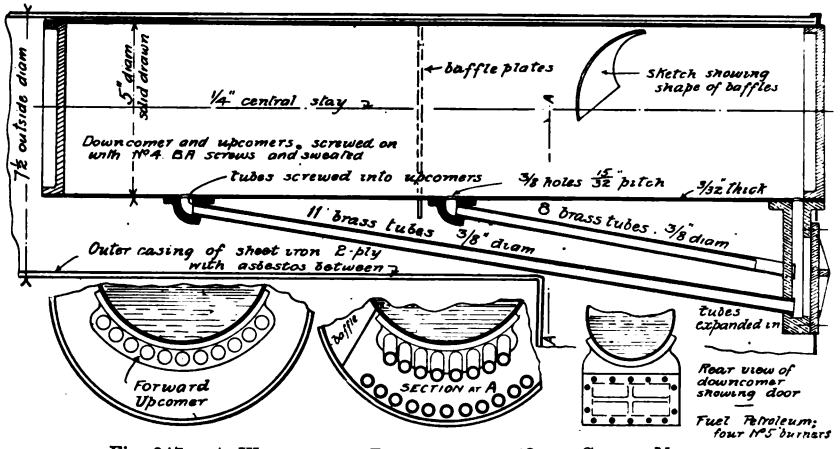

7½ outside diam
5" diam solid drawn
¼" central stay
baffle plates
sketch showing shape of baffles
Downcomer and upcomers screwed on with No 4 BA screws and sweated
tubes screwed into upcomers
⅜ holes 15/32 pitch
3/32 thick
11 brass tubes ⅜" diam
8 brass tubes ⅜ diam
Outer casing of sheet iron 2-ply with asbestos between
tubes expanded in
Rear view of downcomer showing door
Fuel Petroleum: four No 5 burners
Forward Upcomer
baffle
SECTION AT A

Fig. 247.—A WATER-TUBE BOILER FOR A 6½-IN. GAUGE MODEL.

of larger scales. Fig. 247 is a design by the writer for a boiler for an old model locomotive in which the original locomotive type boiler was not sufficiently powerful.

The model, a four-coupled six-wheeled express, was provided with a very short coupled wheel-base, and instead of having a firebox at least $9 \times 5\frac{1}{2}$ in. outside, and 600 sq. in. of heating surface, had only a 6×5 firebox and a total heating surface of 428 sq. in.

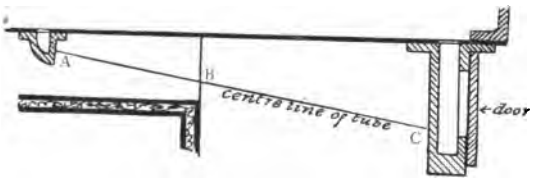


Fig. 248.—SETTING OUT THE TUBES OF A LARGE WATER-TUBE BOILER.

As an extension of the firebox would have entailed a great deal of alteration in the structure of the model, a water-tube boiler worked by oil fuel (Primus burners) was suggested.

The boiler proper measures 5×22 in. and the outer shell $7\frac{1}{2}$ in. The former is of $\frac{3}{32}$-in. thick copper, and the latter

two thicknesses of sheet iron with asbestos between. The chief point to be noticed is the arrangement of the water tubes and their connections. The downcomer is provided with a door at the back, and two rows of $\frac{3}{8}$-in. tubes are passed through and screwed into two upcomers. The upcomers and downcomers are screwed to the already tinned shell, with $\frac{1}{8}$-in. brass screws, and are then thoroughly sweated. All the bottom row of tubes have been set out so that they just clear the throat plate, as shown in the cross-section at this point. To accomplish this, on the drawing the point of the intersection of the centre line of the tube at the face of the upcomer (A) and its proper position at the throat plate (B) should be connected by a line which, if produced to the downcomer, gives the centre of the hole to be drilled in the latter (see C, fig. 248).

As the boiler under consideration is a large one, a baffle plate is so fixed that the heated products of combustion must turn down and pass again through the tubes half-way along the barrel. The arrangement of the lower row of tubes at the throat plate ensures that gases do not in any degree pass away without going completely through the tubes, as would be the case in a boiler arranged in the manner shown in fig. 249. Of course the draught is retarded, but the benefits which accrue from thoroughly abstracting the heat from the gases more than make up for any loss in this direction. Heat is prevented from passing the tubes at the sides by the flame guard, which extends upwards to about the level of the outer tubes in the lower row.[1]

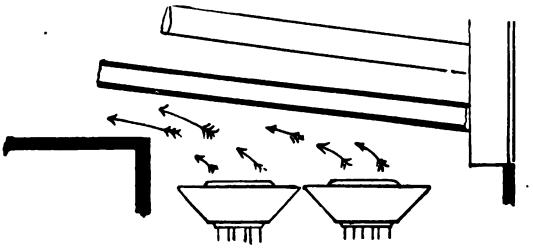


Fig. 249.

Having in some measure exhausted the applications of the

[1] In methylated spirit-fired boilers of smaller dimensions such coercive measures should not always be adopted. It will be worth while to use a smaller number of tubes with proportionately wider spaces between them, and not attempt to check the draught for the sake of gaining a slightly increased nominal heating surface.

water-tube boiler to the model locomotive, attention may now be directed to the modelling of the type of steam generator in universal use for locomotive purposes, from which it earns its name. With general reference to the merits and demerits of the loco boiler for models, it may be said that smaller engines (models of $\frac{5}{8}$-in. scale and under) will do very much better with a water-tube boiler than with an ordinary fire-tube boiler, more

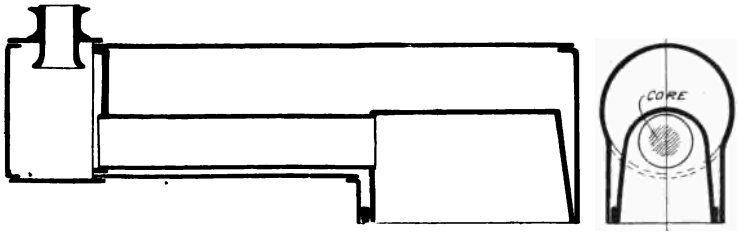


Fig. 250.—A Simple Loco-type Boiler.

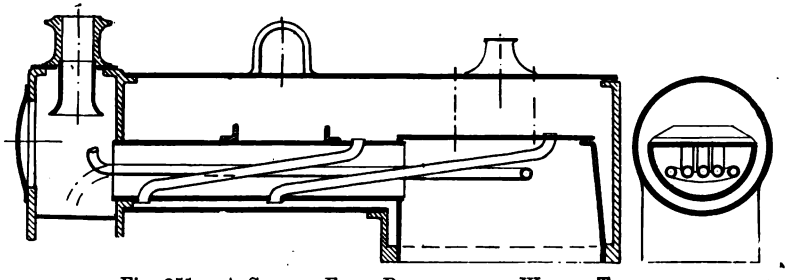


Fig. 251.—A Single Flue Boiler with Water Tubes.

especially in the hands of a novice, and when fired with methylated spirit wick lamp.

For larger engines the water-tube generator will of necessity have to be more complicated in construction, and although a properly designed boiler of this type will have less heating surface than a loco-type boiler, the value of the heating surface will be higher. But whenever the engine is to be ridden upon and sufficient grate area is obtainable, a coal-fired locomotive boiler will prove superior to any of the previously described water-tube generators.

The accompanying fig. 250 shows what may be considered as the simplest possible form of locomotive boiler, the most important modification being that instead of it having a large number of small diameter flue tubes passing through the barrel, it is provided

with one big tube only. No great results must be expected from such a model boiler without the use of water tubes, and even then the power of the boiler is very small indeed. Simplicity is obtained at the cost of efficiency. The single flue, as well as providing little heating surface, allows a large amount of the gases of combustion to escape without giving up the heat contained therein, the central core not coming in contact with the walls of the flue.

An alteration which will render a single-flue boiler more powerful consists of fitting cross water tubes to the flue. (Water tubes

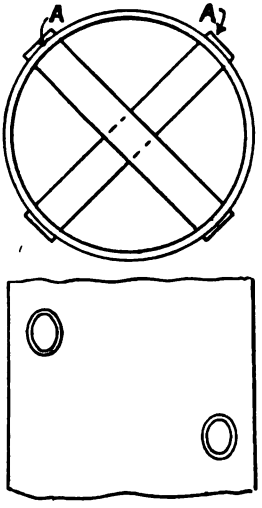


Fig. 252.

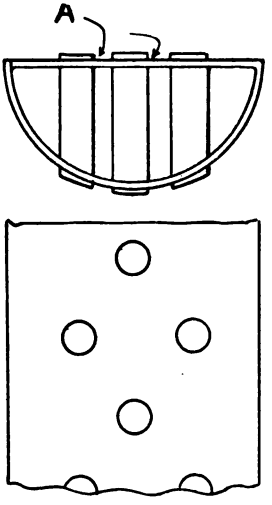


Fig. 253.

in the firebox improve most model boilers, and therefore may be left out of the question for the moment.) This course (see figs. 252 and 253) is open to the serious objection that the boiler must be pulled to pieces if the joints (A) at any time fail, and leakage is certain to occur sooner or later if the tubes are only soft-soldered into the flue.

A further improvement suitable in engines up to $\frac{3}{4}$-in. scale, is the use of D or ○ shaped flue having a number of small vertical water tubes as shown in fig. 253. The water tubes not only increase heating surface but break up the central core of heated gases which would otherwise be wasted up the chimney. Another method is to arrange water tubes running upwards from the front to the

crown at the firebox end of the flue, or into the back end of the firebox crown if flue and firebox are built up before they are placed into the shell. The tubes should not be inclined from right to left, for obvious reasons. None of the foregoing designs should be in any way 'over-cylindered,' and except that an efficient superheater pipe is easily arranged and the draught is naturally a little freer, the greater number of joints, inherent weakness of the D-flue and smaller heating surface, all detract from the few advantages to be gained by the employment of any of the various forms of single-flue boiler. Again, the bottom half of the single flue is of little or no use for evaporative purposes.

As multitubular boilers are quite practicable even for the smallest model locomotive if a suitable size of flue tubes is used

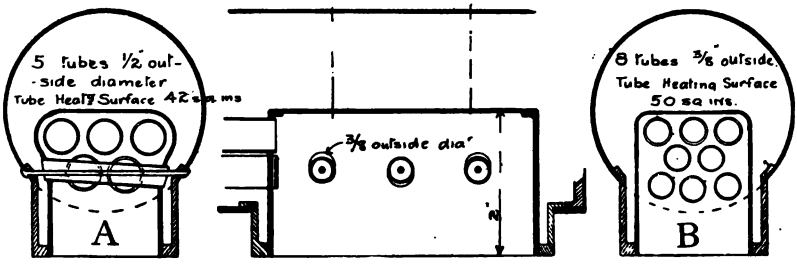


Fig. 254.—FIREBOX AND TUBES FOR A ½-IN. SCALE ENGINE.

(see table, page 53), although the water-tube boiler may be considered in some respects superior for tinier models, a few designs of fire-tube generators are included herewith, different methods of construction in each case being employed.

Fig. 254 illustrates to a scale of ⅜ full size a suitable arrangement of tubes and firebox for a ½-in. scale engine to be fired by an ordinary spirit wick lamp. The cross-sectional view (A) shows a firebox bulged out so as to get the maximum area of tube plate (and therefore the greatest number of tubes) and provided with five ½-in. tubes. With a *straight*-sided firebox and ⅜-in. tubes (B), larger heating surface can be obtained, which most likely could be further increased by bulging the firebox as indicated at (A). Incidentally the drawing depicts one way of arranging water tubes in the firebox. The tubes themselves, if silver-soldered in place, should prevent the inner firebox from failing, and the stays

passing through the water tubes tie the sides of the outer shell together. The sketch also shows a method of building the boiler which has proved very satisfactory in practice, especially where a cast firebox shell is employed; indeed the latter constitutes the chief point in its favour.

A piece of tube is obtained the correct diameter of the barrel and a square hole is cut in the bottom to the exact dimensions of firebox shell, leaving a short piece of barrel intact at the rear end.

In some cases (see fig. 254) it will be possible to drop the firebox shell through the square hole from the inside of the barrel before the back end is put in, in which case the rivets or screws holding the firebox to the barrel will not be subjected to tensile strains, and to a certain degree the boiler will be stronger, but space occupied by the thickness of this flange inside, unless it is filed away for the lower tubes, will be wasted space, as the crown of the firebox must of necessity be placed so much higher in the boiler. For the back plate a turned cast disc from the same pattern as the front end is alone required. The firebox shown in the drawings is not provided with a firehole. This would improve the boiler, and may be made by inserting a piece of stout $\frac{1}{2}$-in. or $\frac{5}{8}$-in. tube with back nuts as illustrated by fig. 255. This tube should take the place of any stays in the back plate.

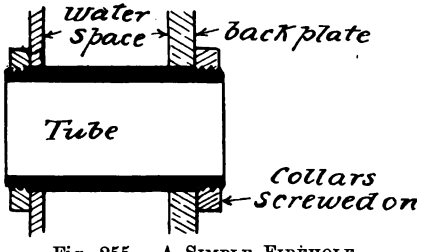


Fig. 255.—A Simple Firehole.

Fig. 256 is a half full-size drawing for a model N.B.R. type of boiler suitable for a $2\frac{1}{2}$-in. gauge engine. It would also fit a L. & S.W.R. engine of Mr. Drummond's build, as the same type of combined dome and safety valve casing is employed by this locomotive superintendent.

The boiler is intended to be built in the more or less orthodox manner, of $\frac{1}{20}$-in. copper plate, except the front tube plate, which should be a circular casting with a flange. The inside firebox is very long, extending over the trailing axle, and, it is suggested, should be made of one piece of plate marked out as shown in fig. 258.

As the boiler should be fired with a spirit wick lamp, and the pressure need not be more than 30 lb., the tubes should be of the thinnest material procurable, and as the principal 'adhesive' used in the construction will no doubt be tinman's solder, in manipulating the boiler, or any loco-type boiler so made, care must be exercised to see that the water is never allowed to become too low and expose the crown, else leakage will surely result. Of course silver-soldering is the only preventative of this, and it is here that the water-tube boiler has the decided advantage. It is possible to get at all joints of a water-tube boiler in a few minutes if the back plate is arranged to come off and all steam pipes to the cylinders are disconnectable by unions.

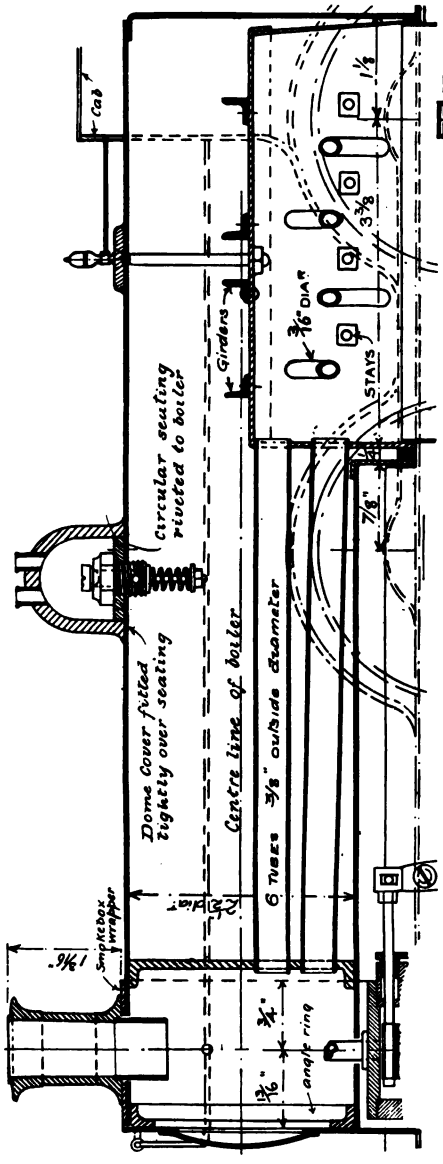


Fig. 256.—A ½-in. Scale Boiler for a Model North British Railway Locomotive.

The roof of the firebox should be supported by two stays and pieces of angle brass screwed from underneath with brass

screws, the whole being sweated with soft solder. To form the smokebox, the boiler barrel is continued to the smokebox front, which may be a flat plate with door, a cast and turned angle ring fitting the barrel being fixed to the front plate. A wrapper plate conforming to the shape of the prototype should be placed over the barrel at the smokebox and secured by flush screws; the space at the back under the boiler being fitted with a throat plate if thought desirable. With this design of smokebox front it will be found very easy to model the front plate in accordance with Caledonian, L. & S.W.R., and S.E. and C.R. practice, where

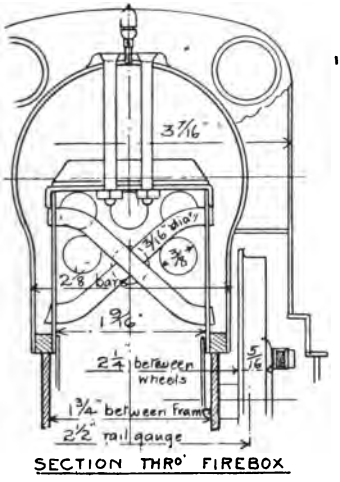


Fig. 257.

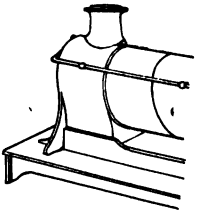


Fig. 259.

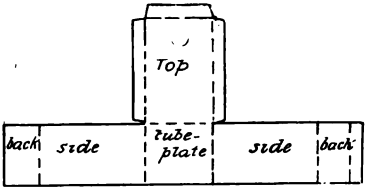


Fig. 258.

this fitting is spread at the base and rests on the footplate (see fig. 259). The boiler would of course be improved by the use of a firehole, as in the last example described.

The two following designs for locomotive boilers are culled from Mr. E. L. Pearce's *Model Boiler Making*,[1] the construction of which in a large measure adheres closely to actual locomotive practice.

Fig. 260 depicts a boiler suitable for a small type $\frac{3}{4}$-in. scale model, in which the barrel of boiler is made from a piece of $3\frac{3}{16}$-in. drawn tube $\frac{1}{20}$ in. thick. The outside firebox plate may be made from a piece of sheet copper, bent round to proper shape, and

[1] *Model Boiler Making*, price 6d., by the publishers of this volume.

riveted to the barrel. The smokebox tube plate and front plate may be $\frac{1}{8}$-in. brass castings, with flanges, the flange to fit the outside barrel being turned, and a light cut taken over the whole

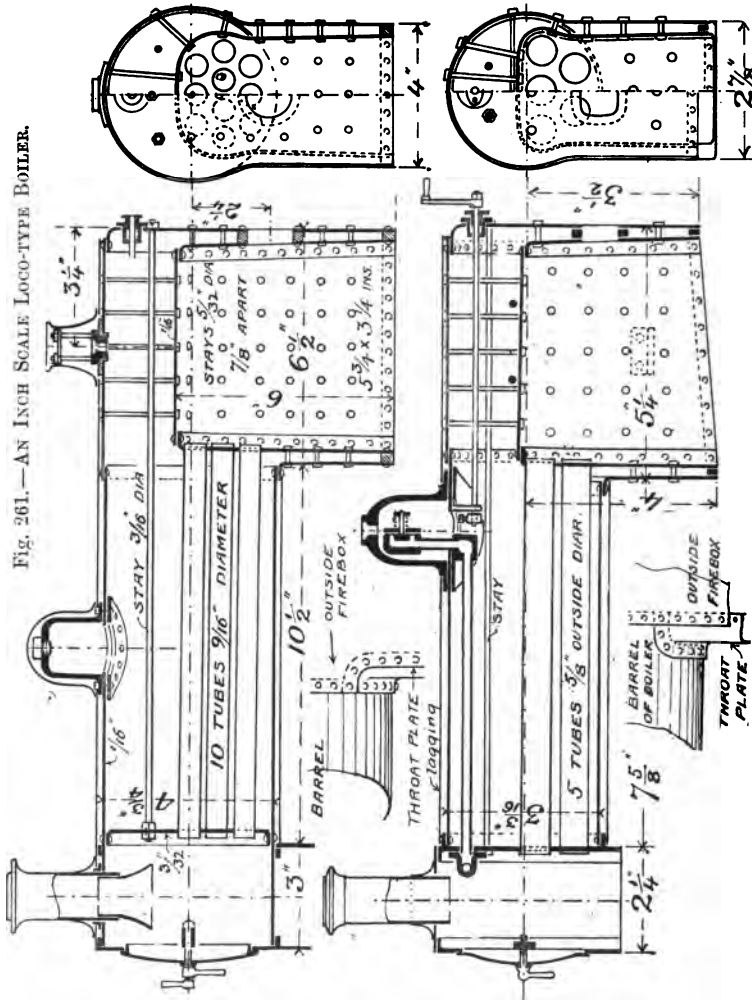


Fig. 261.—An Inch Scale Loco-type Boiler.

Fig. 260.—A Small ¾-in. Scale Loco-type Boiler.

plate on both sides to reduce the thickness slightly. The inside firebox is of sheet copper, the tube plate being $\frac{5}{64}$ in. thick and the rest $\frac{1}{20}$. On referring to the section of the firebox it will be noticed that the tube and back plates are widened out at top to

take in the tubes, and although this entails a little extra work in the flanging, it is quite worth the trouble.

The foundation ring is made from $\frac{3}{16}$-in. square brass, bent to shape, or a pattern can be made for a casting in brass. The sides and top of the firebox are stayed to the shell with $\frac{5}{32}$ in. brass bolts. Holes $\frac{1}{8}$ in. diameter are first drilled through the two plates, the outside ones being afterwards enlarged to $\frac{5}{32}$ in. and the others being tapped. The stays are screwed at each end and screwed into the inside plate from outside, and should project sufficiently at each end for a nut to tighten up. The rivets should be $\frac{3}{32}$ in. diameter and about $\frac{3}{8}$ in. apart.

Fig. 261 shows a boiler for a 1-in. scale engine. The barrel of this boiler is $4\frac{3}{4}$ in. diameter, and is made from one piece of sheet copper $\frac{1}{16}$ in. thick and $15\frac{5}{8}$ in. wide, including $\frac{5}{8}$ in. for a double riveted lap joint, or, if preferred, a piece of drawn tube of same diameter may be used. The front tube plate is circular and flanged all round, and is riveted to the inside of barrel. The front plate of the smokebox is fixed to the shell by riveting or screwing to a piece of $\frac{5}{16} \times \frac{3}{16}$-in. brass, bent to fit outside barrel and screwed to the latter from the inside as shown, a similar strip being fixed at the junction of smokebox to barrel, the lagging plates on boiler and smokebox being flush. The outside firebox plate is made from a piece of sheet copper $\frac{1}{16}$ in. thick, and bent to fit outside of barrel accurately, overlapping $\frac{3}{8}$ in. and riveted.

The inside firebox is $3\frac{1}{4}$ in. wide and $5\frac{3}{4}$ in. long inside at bottom. At the top it is $5\frac{1}{2}$ in. long, and the top is $\frac{1}{2}$ in. above centre line of boiler, and the bottom of foundation ring is $5\frac{1}{2}$ in. below, making firebox 6 in. deep. The top of firebox is supported by direct stays in the usual way.

The sides of inside and outside firebox are stayed together with copper stays $\frac{5}{32}$ in. diameter and $\frac{7}{8}$ in. apart. Three longitudinal tie rods, $\frac{3}{16}$ in. diameter, running the full length of the boiler, stay the upper portions of the front tube plate and back plate of the outside firebox. All the rivets should be $\frac{1}{8}$ in. in diameter and $\frac{3}{8}$-in. pitch. The working pressure of both boilers may be 50 to 60 lb. per sq. in.

In both designs it will be noticed that the wrapper plate of the firebox is separate from the barrel; in one case the plates are

marked out as shown at A, fig. 262, and in the other (the ¾-in. scale boiler) as at B in the same figure.

In most model boilers the joint between the barrel and the firebox may be dispensed with by making the shell in one piece, and whilst the common method of splitting a piece of solid drawn tube as shown in fig. 244, p. 190, cannot be employed for a boiler which must have a deep firebox (except by putting an extra piece on one side of the outside shell of the firebox), one plate for the boiler and firebox shell, marked out as shown in fig. 264, may be used

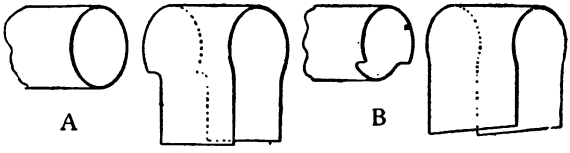


Fig. 262.—Setting-out Wrapper Plates.

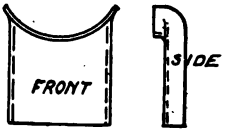


Fig. 263.—The usual Type of Throat Plate.

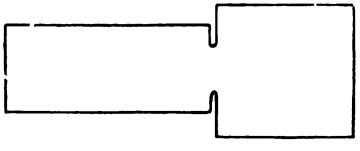


Fig. 264.—A Single-plate Loco Boiler Shell.

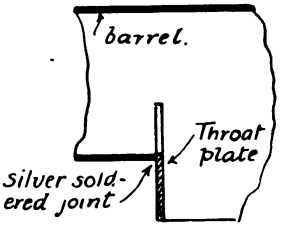


Fig. 265.—A Simple Method of Fixing the Throat Plate.

with advantage. The photograph of the partly finished locomotive (fig. 48, p. 64) exemplifies this construction.

A locomotive type boiler of a size suitable for a ⅝-in. scale front-coupled tank locomotive is illustrated in fig. 266. The firebox in this example is purposely made shallow, and may then extend partly over the frames behind the driving wheels. By this means a wide internal firebox is obtained (see fig. 360), wider than on a ¾-in. scale coupled express (Plate VII.), and in consequence the crown of the firebox may be kept very low and a silent 'Primus' burner employed without overcrowding the furnace space.[1]

[1] Under ordinary circumstances it is impossible to use a 'Primus' burner of the silent type in a ⅝-in. scale model.

As in actual practice the staying of the firebox of a large locomotive boiler with girder stays has been found, amongst other things, to affect the cleansing of the crown of the firebox, and direct staying of a flat crown to a round topped shell being open to objections, the type of firebox shell known as the 'Belpaire' has recently become popular. The photograph of the shell of model 1-in. scale boiler on the next page will give a good idea of the plate flanging and jointing of this type. One point of difference over the ordinary boiler which will be noticed, is that the throat plate extends over the top of the boiler. This plate is a little difficult to flange, but of course a casting may be employed for all boilers built of brass or copper. Its use does away with the three-ply joint at the throat plate, barrel and wrapper necessary in the

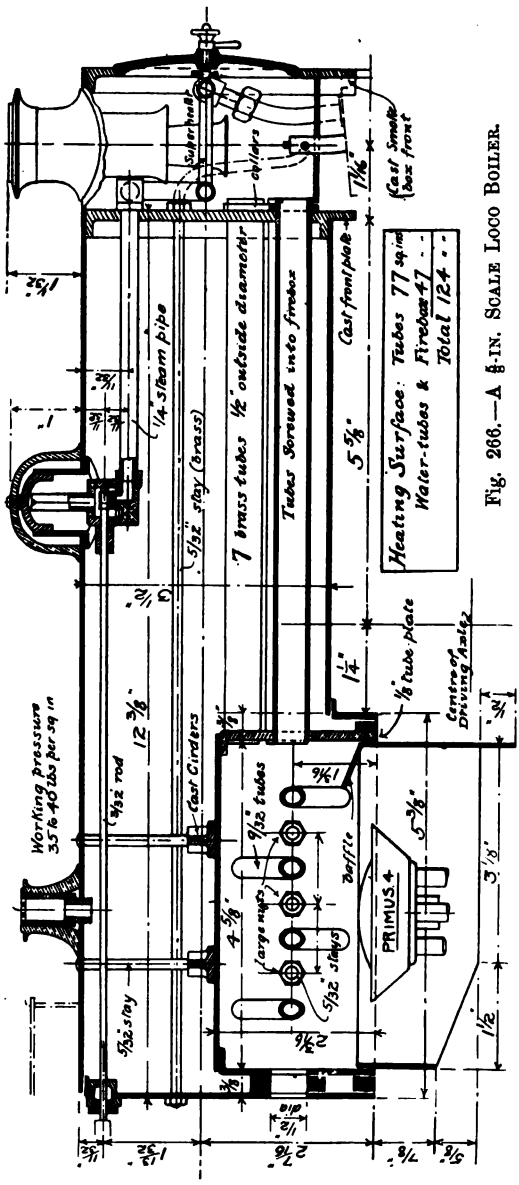

Heating Surface: Tubes 77 sq in
Water-tubes & Firebox 47
Total 124
7 brass tubes ½" outside diameter
Tubes Screwed into firebox
Cast front plate
Cast Smoke box front
Working pressure 35 to 40 lbs per sq in
Cast Cinders
PRIMUS 4
Centred Driving Axle
⅛ tube plate

Fig. 266.—A 1-IN. SCALE LOCO BOILER.

ordinary type of locomotive boiler. Flat surfaces are stayed by bolts to flat surfaces in the 'Belpaire' firebox, full details of which are shown in the accompanying design. This boiler is extremely well stayed, and, if properly made, may be worked at pressures up to 120 lb. The length of the barrel and firebox can be altered to suit any particular engine. The grate is arranged for solid fuel, and nine field tubes are provided, together with a 'brick' arch of cast iron. No dome is shown; this may be added if required, but no advantage will be gained.

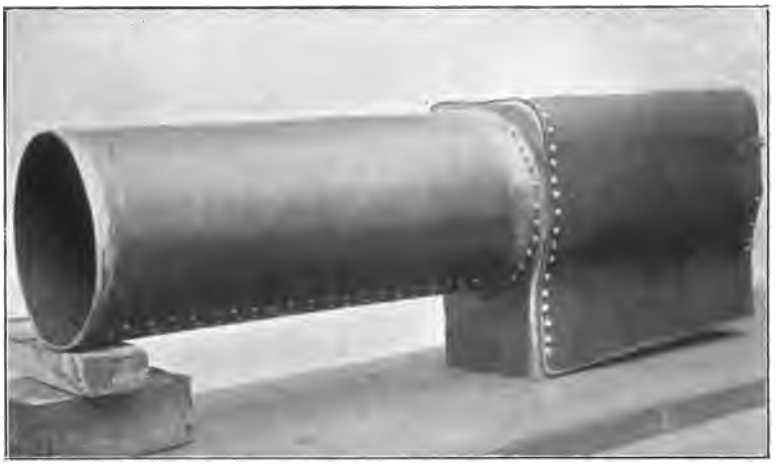


Fig. 267.—A Model 'Belpaire' Boiler, made by Mr. W. C. Roblin.

Mild steel boilers should not be provided with plates of less than $\frac{5}{32}$ in. in thickness, owing to the necessity of an allowance for rusting, and therefore will not be found suitable for engines of under $1\frac{1}{2}$-in. scale. Of course, steel boilers are very much cheaper than those built of copper, the difference being very noticeable in the case of generators for 1-in. scale and 2-in. locomotives, which, if made in copper and steel respectively, would come out to about the same price. Fig. 269 is a detail of the joint of the front tube plate and the barrel and smokebox plates.

Fig. 369, p. 274, illustrates a design for a 2-in. scale boiler of simple but very strong construction, one of which is in use in the model locomotive shown in the frontispiece. This boiler has proved a marked success, upkeeping 100 lb. of steam under

all conditions. The shell is of best Weardale mild steel $\frac{3}{16}$ in. in thickness, and it is riveted with $\frac{5}{16}$-in. steel rivets at a pitch of $1\frac{1}{2}$ in. The crown of the inside firebox fits the sides like a lid of a box, and steel stays $\frac{1}{2}$ in. diameter are used throughout.

Tube Fixing and Setting Out.

In accordance with the best practice for steel boilers having brass tubes, the last-mentioned boiler has the flues expanded into the tube plates. This course is not possible in small models, and it is usual to trust to knocking the tubes over at the ends and soft solder. In $\frac{1}{2}$-in. scale model boilers even this is not practicable,

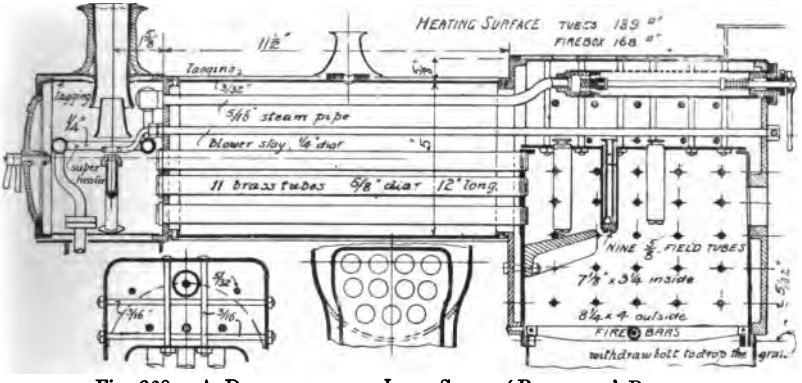


Fig. 268.—A Design for an Inch Scale 'Belpaire' Boiler.

because of the lightness of the plates and tubes involved; and if not silver-soldered, the jointing can only be done with soft solder.

For model boilers of medium dimensions built of copper and brass the method of tube fixing indicated in fig. 270 is strongly advised. The firebox tube plate should always be of brass and of fair thickness ($\frac{1}{8}$ in. in $\frac{3}{4}$-in. scale engines) and the tubes should be screwed with a brass or other fine thread, which should be chased taper as shown. The front (smokebox) tube plate should be a casting if possible, and the tube, being provided with a slot at the end to take a wide screwdriver, should be coated with soldering flux (or tinned) before fixing, so that on sweating up the boiler will be quite tight. The front end of the tube should have a collar driven over the end, soft solder securing the whole. The screwed ends of the tubes will never become leaky even if the water be

repeatedly allowed to run very low in the boiler; and should any leak occur at the front end, it can always be made good with little trouble. The collar, which increases the strength of the joint at the front, may be slightly recessed into the front tube plate with

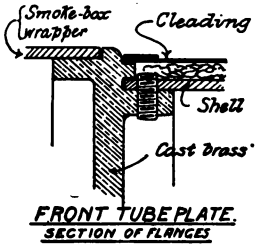


Fig. 269.

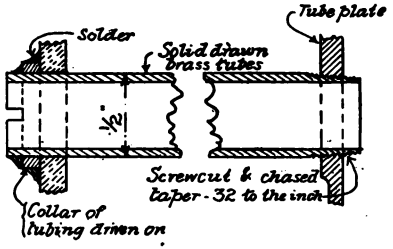


Fig. 270.—Fixing Flue Tubes.

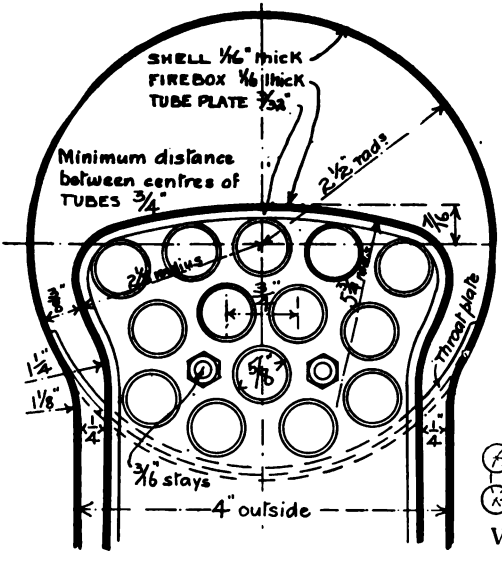


Fig. 272.

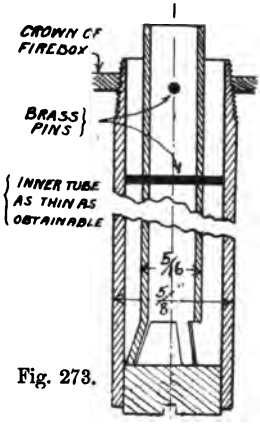


Fig. 273.

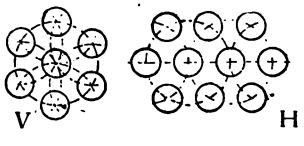


Fig. 271.

advantage. Tubes fixed in this manner can at any time be removed. Tubes may either be arranged in vertical rows as shown at V or in horizontal rows as shown at H in fig. 271. However, the number of tubes in tube plate of a model boiler being comparatively small, the shape of the tube plate and the size of the tubes will very largely dictate the arrangement of

tubes; and often it will be found worth while to vary the rule for size given in the table on page 53, to obtain a better disposition of the flues. A reference back to fig. 254 will show what is meant by this, the method of placing the tubes shown at A in illustration being very much more scientific than that at B in the same figure; and in spite of the larger heating surface provided by the $\frac{3}{8}$-in. tubes, the former is to be recommended—that is, if the bulging of the firebox tube-plate in the example B will not lend itself to a still more advantageous arrangement of tube spacing.

Fig. 272 illustrates a very good spacing for an inch scale engine with a 5-in. boiler barrel, and it will be noticed two longitudinal tube plate stays are possible in this case. The rounded top of the firebox adds considerable strength to the crown.

Water Tubes.

Of late years the use of water tubes in the firebox of model boilers has been adopted with success. There are several methods of fixing, and the one described by fig. 254, page 196, is one of the simplest methods. However, if the tubes are to be silver-soldered in, as they always should be, difficulties will arise during this operation owing to the tendency of the firebox shell to warp whilst in the fire and upset the joints. The straight tubes cannot be inclined to an ideal degree, and except in special cases it will be found worth while to use bent water tubes of the patterns shown in figs. 257 and 344, pages 199 and 243.

'Field' tubes present an improvement over the straight and slightly inclined cross tubes, and at the same time may be very easily fixed by screwing into the crown with a taper thread in the same way as the flue tubes already referred to. A detail of a 'field' tube suitable for a 1-in. scale model is shown in fig. 273. For smaller models 'field' tubes may be $\frac{1}{2}$ in. diameter outside.

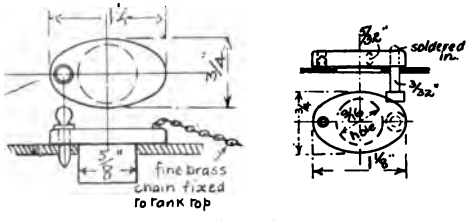


Fig. 274.—Tank Lids.

CHAPTER XI.

Boiler Mountings and other Fittings.

Having explained the construction of the boiler, and in Chapter IV. given rules, etc., to help in the design, we will now consider the numerous fittings necessary to the safe working and the manipulation of the model locomotive boiler, dealing with each item separately, and commencing with

Safety Valves.

The Ramsbottom duplex safety valve is by far the most common to locomotives of this country, and is usually completely cased in. It is not possible to make a good working model Ramsbottom valve for a locomotive to a scale less than $\frac{3}{4}$-in.—indeed the writer does not advise them for that size of model. There is no need for the two valves, and the means for adjusting the spring cannot be satisfactorily arranged. Fig. 276 illustrates a design for a $\frac{3}{4}$-in. scale Caledonian model. Here the tension of the spring is altered by the nuts on the under side of the base of the valve (the steam joint must be broken to do this), and the movable pivot on the forward point of the lever is necessarily omitted. The points should be very sharp, and the valves should be countersunk so that the contact is below the level of the seating of the valve. Fig. 277 shows a type of safety valve in which the adjusting nut is not placed inside the boiler, and in which no upper casing is employed.

Plate IV. ($\frac{3}{4}$-in. scale L. & N.W.R. model locomotive) illustrates to half full size a valve in which the external appearance is retained and a single direct loaded spring valve is employed. The lever is not entirely an ornament, but can be used to ease the

valve should occasion require. The upper casting is separate from the base, and forms a very handy screw water-filler and washing-out plug for the boiler. The holes leading to the central passage are drilled horizontally, and are four in number.

In engines having uncased Ramsbottom safety valves, as in fig. 277, where it is not thought worth while to exactly copy the prototype, the modification illustrated by fig. 278 may be adopted, the front column being a sham, and forming the fulcrum for an ordinary lever type of valve, the spring being in the cab. The central

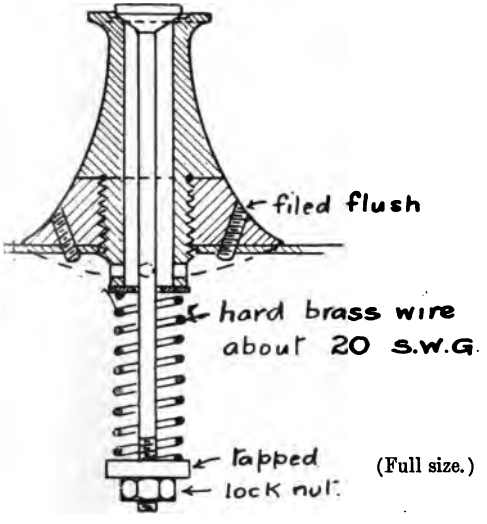


Fig. 275.—A Great Northern Railway Safety Valve. (½-in. Scale.)

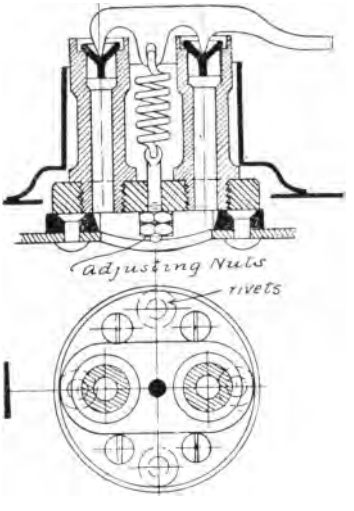


Fig. 276.—Ramsbottom Safety Valve.

spring should be fitted for sake of appearance, but should not take any part in the working of the valve. Sometimes the safety valve is placed on the top of the steam dome, as in the older Midland, new L. & S.W.R. and some Scottish engines. Fig. 279 herewith and the illustration (fig. 256) on page 198 show the arrangements which may be employed in such cases. The dome in the latter example, which is intended for a ½-in. scale model North British Railway locomotive, is not used for the main steam supply, the dome with its two dummy safety valve columns on top covering the safety valve proper. The circular pad for the safety valve seating, which should be hexagonal for use as a filler, should be

riveted to the shell, and the dome cover should fit the pad quite tightly, so that it will not fall off.

The type of safety valve casing used on the G.W., N.E., Midland and G.N. Railways, is very often favoured by model makers because of its simplicity, neat appearance, and the fact that it may be to a large extent finished in the lathe. The full size drawing for a ½-in. scale valve shows a method of making a G.N.R. valve, no outer casing being employed. The body of the valve is in halves with the bottom portion secured to the barrel of the boiler by flush pins, the upper part screwing into the latter. The drawback to this valve is the liability of damaging the polished exterior of the removable portion by screwing it in and out. This evil is somewhat mitigated by the valve shown on Plate IV., the upper part of which is not circular and can be unscrewed with the fingers, but as the circular column is a feature in design of G.N.R. locomotives, the only way of overcoming the trouble is to make the casing entirely separate, as shown in fig. 280.

To make this valve, a piece of stout tube ½ in. in diameter is procured and one end closed by silver-soldering in a disc; the inside of the other end is tapped with a brass thread. To fit this a piece of brass rod should be bored for the steam way and screwed outside with a continuous thread to fit the tube. This nipple is screwed into the boiler and sweated, the hole being prepared at the top to receive the valve. The remainder of the work is simple, the spring being of steel with the ends nicely squared and the valve being thoroughly ground-in quite steam-tight. To increase the pressure on the valve the tube should be screwed further down on to the nipple. The closed end of the tube is intended to be perforated with three holes for the escape of the steam and one for the central valve stem. The casing fits the tube and should require no fixing. The valves of larger model locomotives may with advantage be quite separate from the stem as shown in fig. 282, which illustration depicts another substitute for a cased-in Ramsbottom valve. This type of valve is to be recommended for all sizes of model engines.

Another kind of safety valve similar in general arrangement, if not form, to the type shown on Plate IV., is shown in the accompanying illustration (fig. 281). The spring is inside and yet does

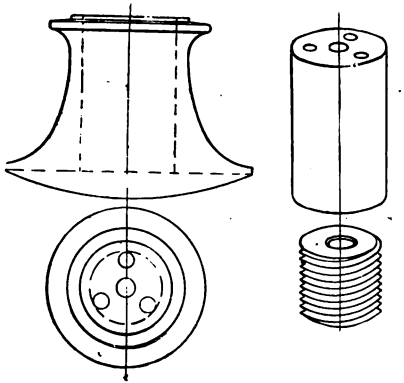
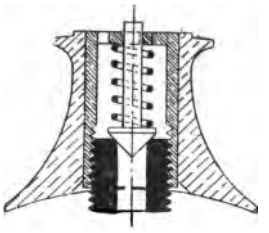


Fig. 280.—A Great Northern Railway Type of Safety Valve.



(Full Size.)
For ⅝-in. Loco.

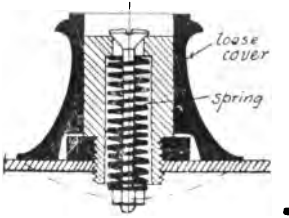


Fig. 281.—Safety Valve for Model ½-in. Scale North-Eastern Railway Loco.

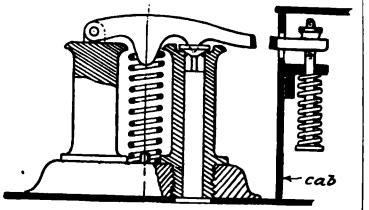


Fig. 278.—A Modified Ramsbottom Safety Valve. (½-in. Scale.)

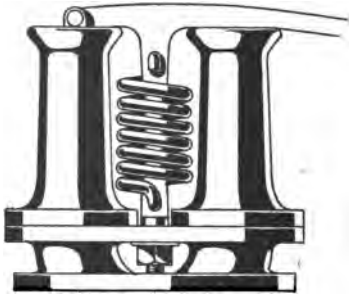


Fig. 277.—Uncased Ramsbottom Valve. (¾-in. Scale.)

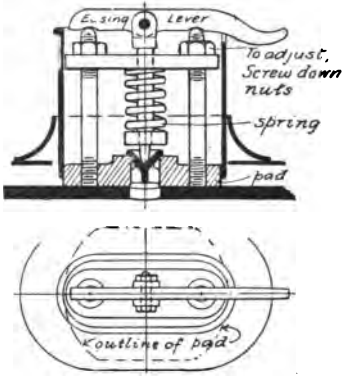


Fig. 282.—A Simple Safety Valve.

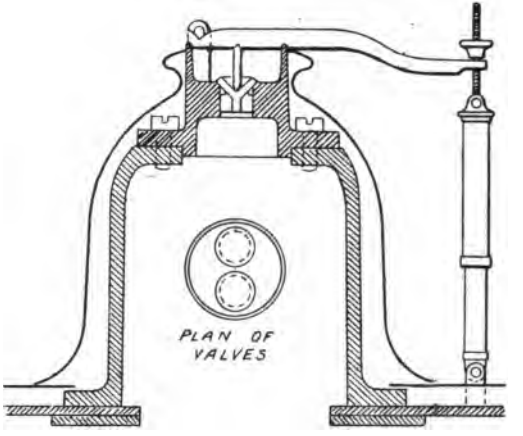


Fig. 279.—The Midland Dome and Spring Balance Safety Valve.

not in any way interfere with the staying and piping of the boiler. Covered with a casing, the fitting may represent either a Ramsbottom or G.N.R. type of safety valve.

DOMES.

Domes are used to provide a means of taking the steam as far as possible from the water level, and whilst in larger engines the dome will generally contain the regulator, for the tinier model it will be

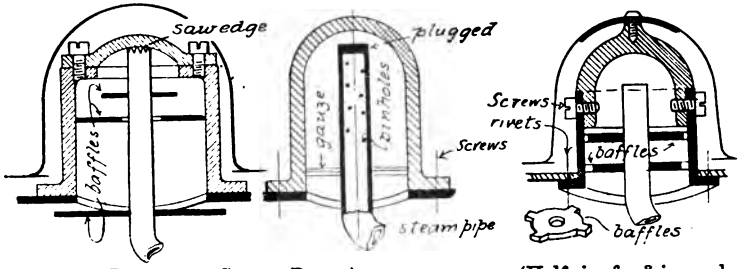
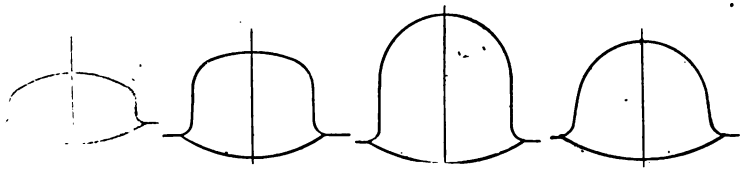


Fig. 283.—DOME AND STEAM PIPE ARRANGEMENTS. (Half size for ¾-in. scale.)



G.E.R. 'Decapod.' G.N.R. '251.' G.W.R. Bogie Singles. G.C.R. 'Atlantics.'

Fig. 284.—TYPICAL DOME COVERS. (¼-in. scale.)

found convenient to simply take the steam from the uppermost part of this fitting by a piece of pipe. This method lends itself to the use of baffling arrangements such as are shown in fig. 283, these sketches (and fig. 305, page 223) also illustrating four methods of fixing the dome to the boiler.

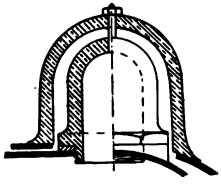


Fig. 285.

The dome in a water-tube boiler, if fixed in the ordinary manner, preventing the ready removal of the barrel from the outer shell, it will be found better practice, where the feature is not used solely as an ornament, to arrange that the inner dome may be easily

taken off. A method accomplishing this object very well is shown in fig. 285, the dome forming an excellent boiler filler also.

It is never advisable to use a dome as a steam reservoir unless it is provided with an outer casing, non-conducting material such as asbesto or wood intervening; and therefore if cost or time is a consideration, then the dome may be used in the manner shown in many of the designs contained within the covers of this volume, simply to imitate the prototype in external appearance.

Even if the dome is not used for the main steam supply, this fitting will be found useful for the blower and injector and other steam pipes, a direct connection to the boiler of these pipes sometimes leading to stopped-up passages through the proximity of the exit holes to the surface of the water in the boiler, floating foreign matter contained therein very often entering the pipes when the model is being carried about and not under steam.

Owing to the increase of the height of the boiler centres of modern engines there is a tendency to flatten the dome, several patterns treated in this manner being shown in the accompanying fig. 284.

Chimneys.

In the chapter on boiler design the care necessary in the design of the chimney is emphasised, and whilst the external form of the fitting will not affect the running or steaming of the model, a badly-proportioned funnel will ruin its appearance.

Fig. 286 is a 1-in. scale detail of the very neat design used on the latest L. & T.S.R. tank engines, and is fitted to a smokebox some 5 ft. 5 in. in diameter (see Plates VIII. and IX.). The writer has noticed that irrespective of height the best external effects are obtained when the diameter of the funnel at the thickest part of the stalk is to the diameter of the smokebox in the proportion of about 1 to $3\frac{1}{2}$ inches. Various designs of funnels are here given to the uniform scales of $\frac{1}{2}$ inch to the foot.

It will be seen from these drawings that the stalks of some chimneys diminish in diameter as they approach the cap, but it must not be concluded that the inner diameter does so as well. Such chimneys are universally provided with liners with the opposite taper, for reasons of efficiency in the matter of the draught

induced by the exhaust. Chimneys in real practice are either built up out of plate material or cast in iron.

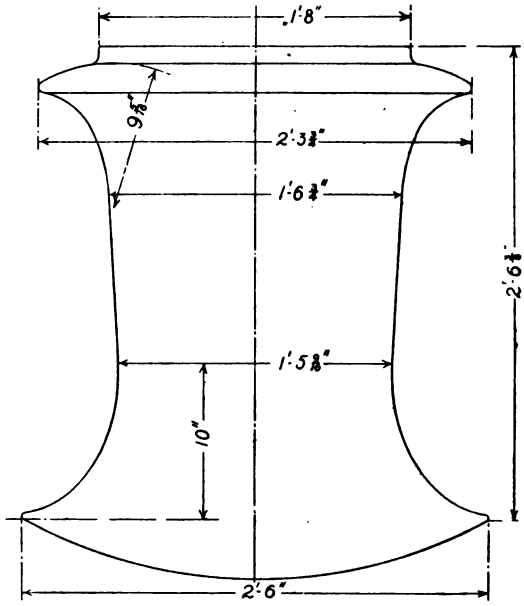


Fig. 286.—L.T.S.R. STANDARD CHIMNEY.

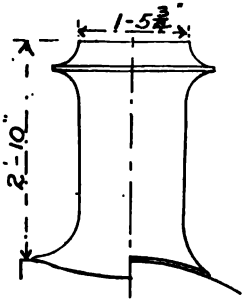


Fig. 287.—L.Y.R. (⅜-in. scale.)

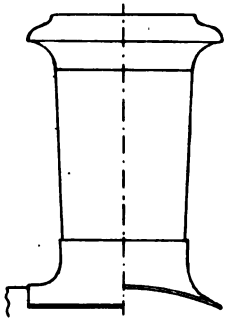


Fig. 288.—L.N.W.R.

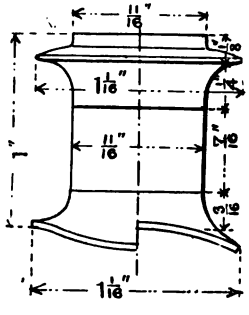


Fig. 289.—G.E.R.

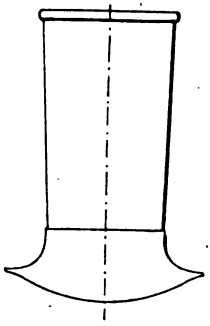


Fig. 290.—OLD G.E.R. AND L.S.W.R.

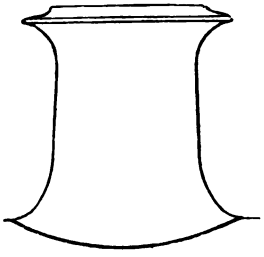


Fig. 291.—L.B.S.C.R.

Except in the case of the latest G.N.R. chimneys, which have the shoulders indicating separate pieces, a cast iron chimney has no lines distinguishing base, stalk and cap.

Cab Arrangements and Fittings.

In the cab of the smallest model locomotive two fittings are always advisable:—a water gauge (or other means of ascertaining

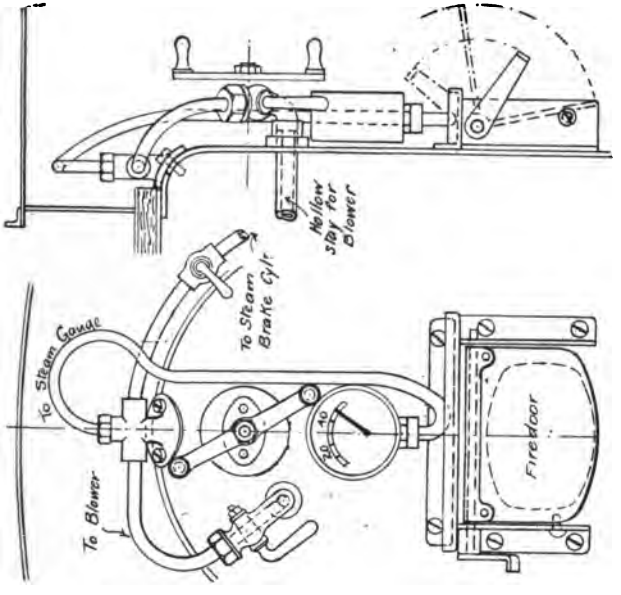


Fig. 293.—Cab Fittings for Model ¾-in. Scale Caledonian Railway Locomotive. (½ full size.)

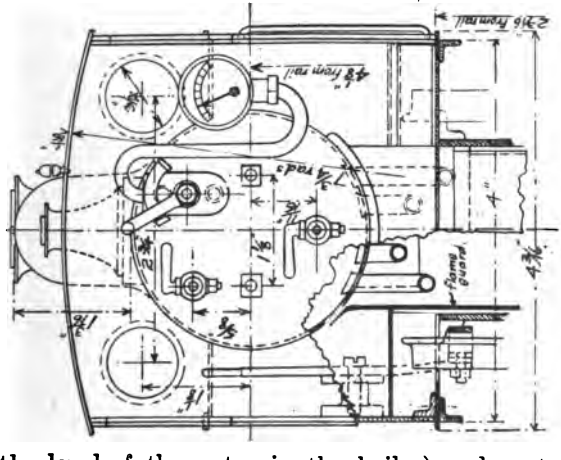


Fig. 292.—Cab View of Simple Model Locomotive. (Half size.)

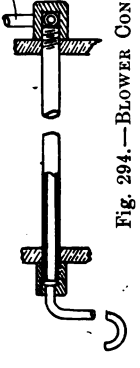


Fig. 294.—Blower Connections.

the level of the water in the boiler), and a steam pressure gauge. A regulator is usual, but in some cases may be dispensed with if a

reversing gear actuated from the cab is employed, or the smoke-door regulator shown on Plate II. (½-in. scale N.E.R. locomotive) adopted.

The cab fittings for a simple model (see page 251) will be explained by a reference to the accompanying fig. 292. Here a water-gauge is not used, and in its place two 'try' cocks, one to indicate the highest and the other the lowest water level admissible. The regulator box (see detail on page 222), which is on the outside of the back plate of the boiler, affords a means of connecting the steam gauge to the boiler, the pipe for which is bent to form a syphon. The gauge is ¾-in. diameter, but wherever possible the writer advises that these useful fittings should be of the largest diameter possible. Instead of coiling the pipes to make a syphon, which by the way is essential, inasmuch as the accuracy of the gauge is preserved for a longer period, very neat special fittings fulfilling the same purpose are now obtainable.

As larger model locomotives almost always have a firehole, even when oil-fired, some sort of a door is essential, and the 'lift-up' and 'slide' door patterns are to be recommended as the best. Fig. 293 illustrates the fire-door and fittings for the cab of a ¾-in. scale engine in which both brakes and blower are provided for. To save drilling a large number of holes in the boiler, a casting may be made for a three-way boiler junction. This should be correctly faced, sweated on and further secured by two brass screws to the curve of the back plate flange. The right-hand branch should have the steam-brake pipe screwed into it, a stopcock being placed in a convenient position on this pipe. The centre branch should be screwed for a union for steam gauge pipe. The position of the steam gauge is about the only one convenient for the ¾-in. scale model; in a model to a larger scale the steam gauge can very well be placed in the usual position, the right-hand junction being used for this, and the centre one connected to the brake. The steam gauge in the position shown will be more easily seen than if it is placed up near the roof of the cab.

The left-hand junction is the blower connection. One of the longitudinal stays through the boiler should be hollow—of $\frac{3}{16}$-in. solid-drawn tube—and the nut at back plate should be a special one, and project beyond the end of tube-stay, so that a bent cock

may have its nose screwed into it. A small pipe should be screwed into the junction at one end, and be affixed to the union at the other. Another method of connecting the blower to the hollow stay is shown in the sketch, fig. 294, and on Plate III.

Where separate steam pumps or injectors have to be fed, the number of branches must be increased according to the special requirements.

To more or less protect the fittings on the 'boiler front,' a tray may be made from plate material, and be attached to the back plate with screws, as shown in fig. 293.

The side plates of fire-door should have holes drilled to take the spindle of fire-door, and the door can either be brazed to the spindle or folded over and secured by set-screws in the manner indicated. The handle of the fire-door should be at the side, and made so that it will clear the tray. The door should be arranged so that it works stiffly, and will remain up when required. To prevent the door closing tight, a set-screw should be placed inside the plates, this screw being arranged in the best working position. It is always advisable that some air should enter the fire-door, so that the combustion may be rendered complete.

Smokebox Arrangements.

Roughly speaking, the smokebox of a locomotive will contain the exhaust and steam pipes, the blower (if any) and, in the case of a tubular boiler fired by solid or oil fuel,[1] the superheater, should this invaluable accessory be employed. Space must be allowed for petticoat pipes, which add greatly to the efficiency of the blast, and in a 2-in. scale model it will be found that there is no great amount of room to spare in the smokebox even if it be of ample dimensions. The various fittings should not, in a coal or charcoal-fired model, be arranged in such a manner that the sweeping of the tubes is in any way hindered.

It is generally a safe procedure to provide as much flexibility in the steam pipes as is possible, and in addition to the orthodox arrangement of steam pipe, four types of superheaters suitable

[1] Not methylated spirit. In model engines using this fuel the superheater pipes should always be in contact with the flame.

for tubular boilers are diagrammatically sketched herewith, all of which give the desired flexibility.

Where a retardation of the steam in its passage to the cylinder is not advisable, a continuous coil superheater should be avoided—although in small engines of $\frac{3}{4}$-in. scale working on sharp curves without governors or any other system of automatic control this is not a disadvantage, as dangerously high speeds should in some degree be prevented. Therefore, for engines to be ridden upon, the types of superheaters (D) and (E) are the best.

The orthodox system of steam piping may be provided with a single union at the top in place of two, the pipes being attached to the steam chests by ordinary flanged joints (A) (fig. 295). In the other designs two unions are advisable, one each side of the superheater; and if this course is adopted, steam-pipe fixing will never

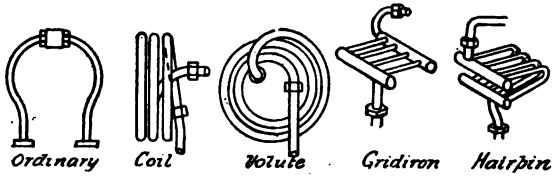


Fig. 295.—STEAM PIPE AND SUPERHEATER ARRANGEMENTS.

present serious difficulty, and experiments to test the value of the superheater can at any time be readily made by substituting the superheater for a short piece of tube. The 'gridiron' and 'hair-pin' superheaters should be designed and fitted in the smokebox so that the small tubes do not come in the way of the blast-pipe, and also in such a way that they are just above the level of the top row of tubes and allow the latter to be easily cleaned.

As in the methylated spirit-fired engines 'flame superheaters' are the best, the Smithie's type boilers will be found to allow of this kind of superheater better than any other, and this is why the water-tube boiler is to be recommended, with fewer qualifications for small work. Smokeboxes should be quite airtight.

BLAST PIPES.

The chapter on cylinders describes various methods of arranging the exhaust pipes of a model locomotive, and for an outside-cylinder

model the construction indicated on page 121, fig. 137, is a good one where the blast-pipe orifice need not be very low down in the smokebox. The two pipes are halved at the junction as shown in fig. 296. If the correct size of blast orifice is obtained by the use of suitable exhaust pipe, 'nozzling' will not be required; but should the same prove necessary, then screwed caps may be made as shown at (A) in fig. 297.

Fig. 296.

Many of the cylinder designs in Chapter VII. requiring only short straight exhaust pipes, the caps just mentioned may be used to bring the orifices to the proper diameters given by the rule on pages 58, to which the reader is referred for fuller information as to size and position of blast pipe and to the arrangement of the petticoat pipes and chimney.

Plate IX. illustrates another method of connecting the blast pipe of an outside-cylinder engine, and Plate VII. shows the usual method adopted for inside cylinders having the valves between, a flanged joint and a plain piece of pipe being employed. Any crevices in the smokebox shell, caused by the passage of steam and exhaust pipes, which would draw air should be stopped with asbestos.

BLOWERS.

Although the single jet blower placed by the side of the blast pipe has the merit of simplicity, and if it is kept sufficiently low in the smokebox will, in small models, serve its purpose very well, an improvement is indicated in fig. 297, in which the jet emerges from the centre of the blast pipe.

(A)

Fig. 297.

For larger models a more efficient arrangement is illustrated in fig. 298. This is a modification of the common ring blower, and is formed by bending a tube as shown, plugging the extremity, and fitting several jets. The length of the tubes may be very much shortened if they are soldered in in the right direction, or plain holes carefully drilled may be employed if preferred. The longer jets allow of bending after the blower is constructed, and may for this reason be retained.

The total area of the blower jets in models often being made

much too large, as a guide the following suitable sizes are given below.

TABLE OF BLOWER JETS.

Small models.	Single orifice of	$\frac{1}{32}$	in. in diam.
$\frac{3}{4}$-in. scale, three jets		$\frac{1}{40}$ to $\frac{1}{32}$	in. in diam.
1 " " four	"	$\frac{1}{32}$	in. in diam.
$1\frac{1}{4}$ " " "	"	$\frac{1}{20}$	" "
$1\frac{1}{2}$ " " five	"	$\frac{1}{20}$	" "
2 " " "	"	$\frac{1}{16}$	" "

SMOKEBOX FRONTS.

As the orthodox smokebox door does not, in models of small scales, allow of much room for getting at the pipes, etc., the doors may with advantage be imitation fittings, the whole front being capable of ready removal should occasion require. Circular smokeboxes will generally be found to facilitate the fitting of such smokebox fronts. All large engines should be provided with absolutely air-tight doors, and to prevent the rapid blistering of the paint on the smokebox of the model, a lagging of sheet iron and asbestos may be arranged both inside the door and around the inside of the smokebox wrapper plate (see fig. 268, page 205).

REGULATORS.

These fittings, as the name implies, 'regulate,' at the driver's will, the passage of the steam to the cylinders, the lever operating the steam valve being situated in the cab. There are innumerable patterns available, but as there is no one which can be satisfactorily employed in all cases, several will be described.

If the builder does not trouble about a realistic arrangement in the cab a plain plug cock outside the backplate of the firebox may be fitted, the steam pipe passing down through the flame and the plug having a long lever attached to it, as shown in fig. 307.

The plug cock may be placed in the base of the dome, as indicated in fig. 302, the rod passing through a gland in the back plate and the orthodox handle employed, or it may be put in the smokebox and worked by a rod passing through a tube, as depicted in fig. 300.

In the latter examples, provision must be made for ready access in case the plug of the cock sticks; the dome should be made easily removable in the arrangement illustrated in fig. 302, and in the other lubrication with some penetrating oil such as paraffin should be resorted to if the dry heat of the smokebox puts the cock out of order. The forcing of the regulator handle should never be attempted.

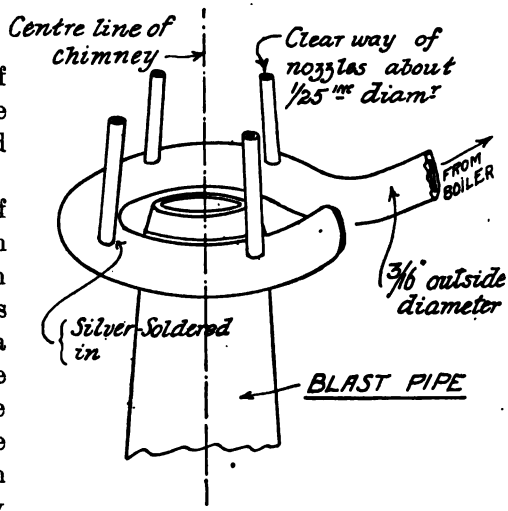


Fig. 298.—Ring Blower.

An improvement of the simple method shown in fig. 307 is detailed in fig. 299, which illustrates a regulator applied to a ½-in. scale model. The drawing shows entrance to the vertical passage closed by a screw which may be withdrawn at any time if it is necessary to lubricate the regulator; but instead of this course being adopted, the blower supply or the steam-gauge pipe may be connected to this hole. The regulator box is illustrated cast with the backplate of the boiler, but it may be made quite separate, as is depicted in Plate IV. and fig. 301. The latter regulators, whilst they embody the same idea, are somewhat improved in construction, the spring which keeps the plug cock in its place being enclosed in a sealed chamber.

A modification of the design has been placed on the market in which the plug is hollow, of the reverse taper, and kept in place by a packed gland. A further alteration of this regulator is illustrated in the model Midland locomotive described on page 260, a detail of which is shown in fig. 308.

One of the best regulators for use in conjunction with the ordinary steam dome is the modified Stroudley type, which consists of a vertical column with a head at the top of the inside of the dome containing the ports. Over these ports a circular valve with

a similar arrangement of ports partially rotates; and when these are moved opposite to each other, steam is allowed to pass from the dome to the steam pipe. A finished regulator is shown in the accompanying photograph on page 226. The valve is actuated by two vertical links attached to levers on the regulator rod, which

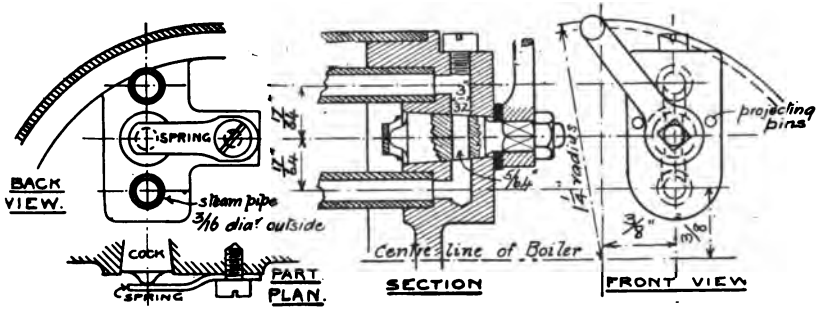


Fig. 299.—A Simple Regulator.

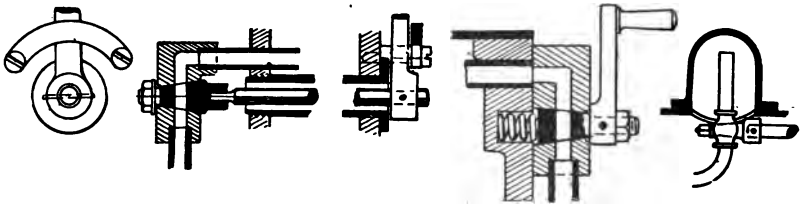


Fig. 300.—A Smokebox Regulator. Fig. 301. Fig. 302.

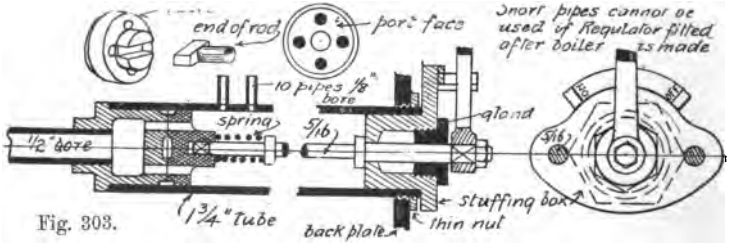


Fig. 303.

passes in the usual manner through a stuffing box in the backplate to the handle in the cab. The drawing of the regulator is half size for an inch-scale model, and shows the column made from a cored casting. It may, of course, be built up from tube and rod brass in a similar manner to the regulator illustrated by fig. 304. This is of the usual slide valve type, the pilot valve used in large

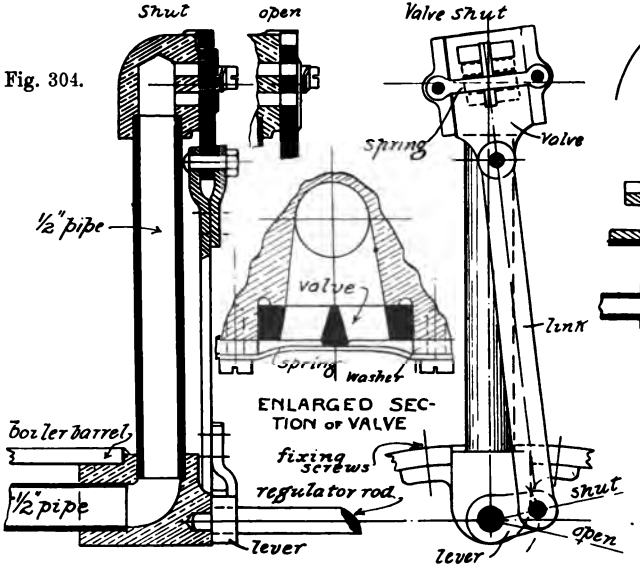


Fig. 304.

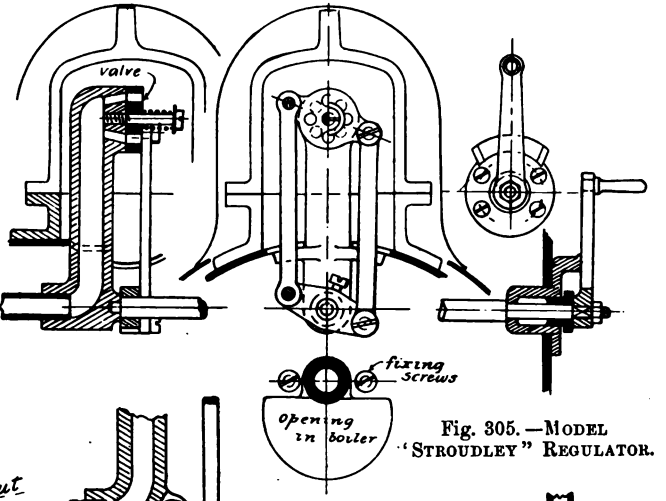


Fig. 305.—Model "Stroudley" Regulator.

(Scale, half size.)

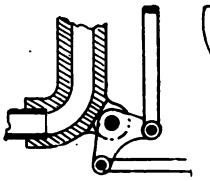


Fig. 306.

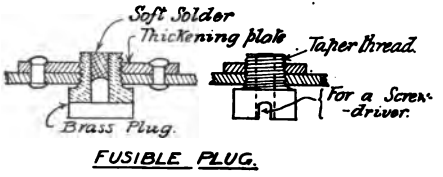


Fig. 310.

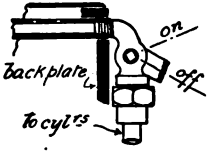


Fig. 307.

Fig. 308.

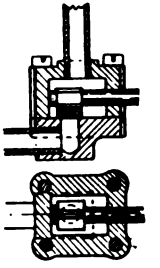


Fig. 309.

work being omitted. A flat brass spring should be fitted to always keep the valve on to its face. This regulator is designed to suit a 2-in. scale locomotive.

For engines built after the latest G.W.R. practice, where boiler with high Belpaire fireboxes and without domes are employed, the regulator shown in Plate V. is a very good one.

The detail drawing, fig. 303, exemplifies the construction of this kind of regulator, and at the same time indicates a modification of some value, the valve, instead of being permanently fixed to the regulator rod, being a separate piece of metal slotted to fit the flattened end of the rod. This freedom allows the valve to make proper contact with the face at all times. In making regulators on this principle, care should be taken to see that the valve and port-faces are recessed so that they do not touch each other at the outside edge or in the centre. The necessity for this will make itself evident when the valve is being made steam-tight by grinding-in.

The majority of G.N.R. locomotives have pull-out regulator handles in the cab, and therefore slightly altered arrangements are necessary according to the type used. In Plate III. a slide valve regulator is shown in which the rod is pulled on and off. Fig. 309 herewith, and fig. 266, p. 203, show a modification of this type suited to engines employing the dome in the legitimate manner.

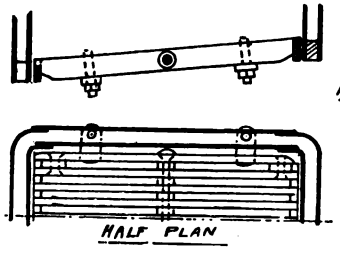
To actuate the regulator shown in fig. 304 by a standard G.N.R. driver's handle instead of the regulator rod rotating, the rod should be fixed to one arm of a bell-crank lever as shown in fig. 306, when the pulling and pushing of the handle will lift and lower the slide valve, shutting and opening the valve to steam.

Fire Grates, Brick Arches, and Miscellaneous Fittings.

Engines burning solid fuel should be provided with a suitable grate made up of rectangular bars placed a distance apart equal to their thickness. To preserve these air spaces 'distance pieces' may be employed as shown in fig. 311, which also illustrates one method of fixing a grate to the firebox. Sometimes it is advisable to arrange the grate so that by the withdrawal of a pin the whole of the fire may be dropped on to the floor in case shortness of water occurs and there is no means of replenishing (see fig. 268).

In larger engines a 'brick' arch should never be omitted, as this useful fitting prevents the passage of cold air directly through the tubes, and by turning over the flames ensures more perfect combustion of the fuel. For upwards of 1½-in. scale models the 'brick' arch is best made of a piece of a fireproof tile (see p. 205, fig. 268, for position), and in smaller engines may be cast in iron. For oil-fired engines using 'Primus' burners, air baffles of sheet iron only are required, as indicated in the designs on p. 203 and Plate VIII.

Fusible plugs are useful to prevent serious damage to the crown



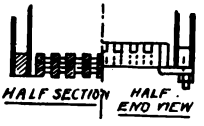


Fig. 311.—Fire Grate.

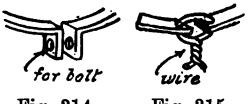


Fig. 314. Fig. 315.
Fixing Lagging Strips.

Fig. 312.—Pump Check Valve.

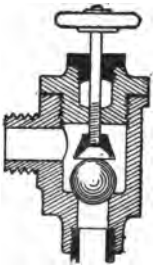


Fig. 313.—Check Valve for Injector. (Scale, half size - for 10¼-in. gauge loco.)

of a firebox, and may be used in the smallest of models. Fig. 310 shows a plug employed with success in a ¾-in. scale model. The central hole should be filled with solder, the plug being screwed into the crown plate with a screwdriver.

Check valves for model boilers may be obtained in all sizes, and except for use with injectors the commercial articles are uniformly successful. They usually have a cock placed between the valves and the boiler, and also a union for the delivery pipe. The small hole in the cock of these valves is the feature which makes them unsuitable for connection to injector delivery pipes. To overcome this, and at the same time to provide a means of preventing the 'leaking-back' of check valves, the design shown in fig. 313 may be adopted.

With cross-head or other automatic pumps nothing whereby

the passage of the delivery can be stopped from entering the boiler and trapped in the pipes should be allowed, otherwise the failure of the pipes or the pump will sooner or later occur through the driver forgetting to open the valve or cock when the engine is about to be moved.

LAGGING.

The lagging of the boiler of a model locomotive with asbestos, flannel soaked in alum or other substance, covered with sheet metal (tinplate, Russian iron or thin hard brass) is not always a satisfactory or interesting task, and in smaller models the absence of such covering will not be felt in any marked degree (the losses from radiation in an uncovered model boiler generally amounting to about 10 per cent.), except when models are worked out of doors in the cooler seasons of the year.

The outer metal covering is called the 'cleading,' and in real engines is laid on in several pieces, the joints being hidden by lagging bands. These bands in models do not usually fulfil the same object, but as they form important features in the external finish, should not be omitted. The widths of the bands employed in actual practice vary from $1\frac{3}{4}$ to $2\frac{1}{4}$ in. For models, strip brass from $\frac{1}{32}$ in. thickness may be procured in widths from $\frac{3}{32}$ in. Figs. 314 and 315 show two methods of jointing the bands at the under side of the barrel.

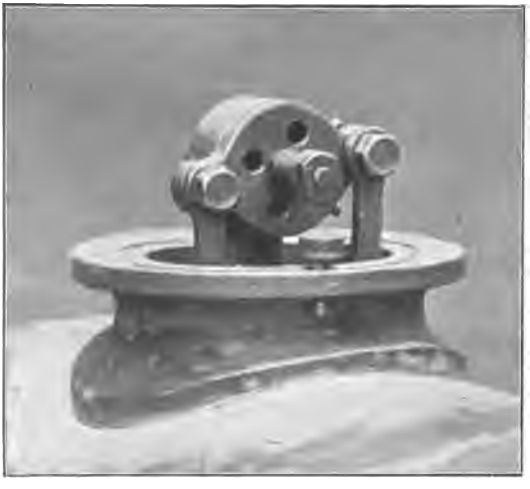


Fig. 316.—A MODEL 'STROUDLEY' REGULATOR.

CHAPTER XII.

Cabs, Tanks, Tenders, Boiler-feeding and Firing Arrangements.

Among the materials which may be used for the superstructures of model locomotives hard rolled brass plate which can be obtained flat and smooth, will suggest itself as the most suitable, although for large engines of 1-in. scale and upwards, the use of sheet steel will reduce the cost of the work considerably.

Aluminium or brass castings and stamped tinplate are also employed by manufacturing firms where models are to be made in bulk. With the first-named, however, it must be remembered that good threads are not always easy to cut in aluminium; and where it is used, the parts made of this material should be those with the greater number of 'clearing' holes, rather than 'tapped' holes, in them. Brass and tinplate lend themselves to the use of soft solder as a jointing material; but for better work hard rolled sheet brass and angle brass will give the strongest structure. Tinplate may be used for small models of $\frac{1}{2}$-in. scale or thereabouts with great success, solder alone being employed as the jointing material.

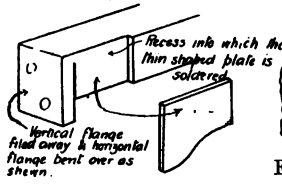
Plates of $\frac{1}{4}$-in. and $\frac{3}{8}$-in. thickness are employed in prototypes, and care should be taken not to use very heavy stuff on the model, especially in the matter of footplates, which show their thickness at the edges, otherwise the appearance of the model will be spoiled. In $\frac{3}{4}$-in. scale models $\frac{1}{20}$-in. plate is very suitable for such work as cabs, tanks, footplates, tenders. Where water is to be contained, brass will prove to be the cheapest material in the end.

Along the edges of the footplates of a locomotive 'webbing' strips are employed, and in all cases the footplates overlap this webbing

or edging (see sketch, fig. 318). The model-maker will find angle brass serve the purpose admirably, and where a shaped finish at the buffer plank is required, the method of construction shown in fig. 317 is suggested.

The vertical plates which carry the steps up to the footplate are often made flush with and form part of the edging, but wherever possible the steps should be set back as indicated by fig. 319. They will then be found very much less in the way, and will not be damaged so frequently.

In building up the splashers, tanks and cabs of small model locomotives, instead of using continuous pieces of angle brass for



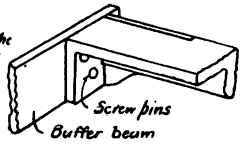


Fig. 317.

Fig. 318.

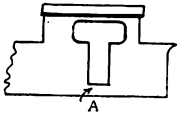


Fig. 321.

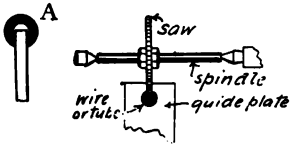


Fig. 320.

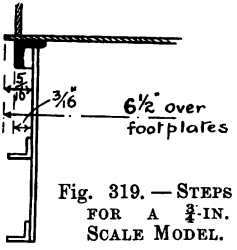


Fig. 319. — STEPS FOR A ¾-IN. SCALE MODEL.

the joining of two plates together at right angles, short lengths of say one inch may be employed, at intervals, the first operation being to sweat and flush pin, or screw the angle to one plate; then the two plates may be brought together and similarly secured, the whole joint being subsequently soft-soldered from the inside with a bit, throughout its length. If any accident should happen to the model, whereby it is subjected to flames, or if further soldering is to be done to the work, it will not fall to pieces in the way it would if no other positive fixing other than soft-soldering were employed.

It is possible to procure half-round brass wire from ⅛ in. wide, which forms very suitable edging or beading for tanks and cabs. Similar material of ▬ section is also obtainable. Disproportionate sizes of beadings sometimes used give a clumsy, coarse appear-

ance to a miniature locomotive, and model makers, in choosing the material, should remember that in the prototype the cross-section of the edgings employed generally measures about $\frac{3}{4} \times 2$-in. For $\frac{3}{4}$-in. scale engines, $\frac{1}{16}$ in. thick $\times \frac{1}{8}$ in. wide is the largest section that should be used.

Small diameter tube or round wire is often required (see A, fig. 320), and may be split (*i.e.* 'slotted') by drawing through a plate held in the slide rest, a saw cutter being placed on a spindle and rotated between the centres of the lathe.

Repairs to both engine and boiler will be greatly facilitated if the splashers, cabs and tanks are made quite separate from boiler, footplates and frames, and also fixed in such a manner that they may be readily removed. The cross-section through the tanks of a $\frac{3}{4}$-in. scale model (Plate IV.), illustrated by fig. 322, shows how this

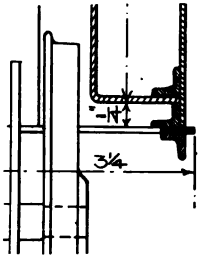


Fig. 322.

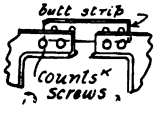


Fig. 323.

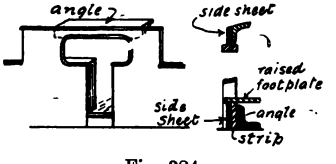


Fig. 324.

may be accomplished in a tank engine, the lower angle, which rests on the footplates, being tapped for screws driven from below through the footplates. It also shows how a considerable amount of labour can be saved by reducing the width of the tanks instead of using all the available space and making semicircular recesses for the coupled wheels. Incidentally this sketch indicates the method of allowing for the connecting and coupling rods clearing the bottom of the tanks, the latter being placed about $\frac{1}{4}$-in. above footplate level in a $\frac{3}{4}$-in. scale model employing $4\frac{1}{2}$-in. wheels.

The designs on Plates III. and IV. illustrate two easy methods of connecting separate side tanks. Side tanks of simple models may be dummy structures. In the model illustrated on Plate VI., this course is adopted, one-half of the bunker only being used for the water supply.

In some designs with covered-in cabs the side sheets of the cab are flush with bunker and tank sides. If one sheet of metal

is used for the whole side, it will be found that the plate is difficult to handle, and unless a joint is made at the top (see fig. 323) the bottom part marked A in fig. 321 will be best left intact until the roof of the cab is fixed on. The design often lends itself to the retention of this connecting piece, owing to a raised footplate inside the cab being used, when the narrow connecting portions may be strengthened by strips and angles soldered on to the inside. However, where flush side sheets are not imperative, separate side tanks, bunker and cab are advisable, as in the designs in Plates III., IV., and VII., otherwise, during repairs, the whole of the superstructures must be removed together—that is, if the paint is not to be damaged by breaking flush joints.

Fig. 325 is a detail of the cab for a ¾-in. scale tank locomotive of the L. & N.W.R. type, the weather-board at the back being quite

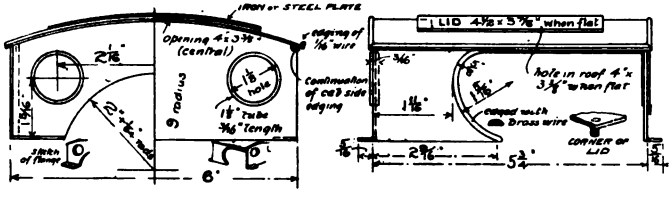


Fig. 325.—CAB DETAILS.

plain at the edge. Both the front and the rear weather-boards are flanged horizontally, so that they may be screwed down to the top of the side and back (bunker) tanks.

To enable the cab fittings of the model to be easily handled a large hole is cut in the roof plate, and to cover this up when the model is out of use a separate roof plate is fitted as shown. This may of course be made to fit flush with the main roof, where a more or less exact scale model of a given prototype is desired (see Plate VIII.).

The photograph (fig. 331) illustrates the partly-finished cab and splashers of a model ¾-in. scale model locomotive. The roof of this cab has a large portion of its after end cut away, this opening being covered by a steel coverplate. The side sheets of the cab and those of the splashers are quite flush. This method, as in the already referred circumstance in tank engines, makes the superstructure rather unwieldy to handle; and if a roomy cab is

desired, the splashers must be extended laterally to the same amount, and may in some cases look rather too wide.

The chief point the picture illustrates is the extension of the rear splashers into the cab, the reversing lever rack being made from the inner side plates of the right-hand splasher. The edging of the windows is also shown by the photograph. Strips of $\frac{1}{16} \times \frac{1}{8}$-in.

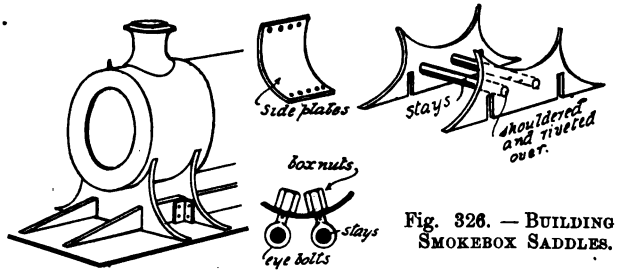


Fig. 326. — Building Smokebox Saddles.

section brass wire left bright are intended to edge the splashers; and to allow the coupling rod and crank-pins to clear the splashers, pieces must be cut out as indicated by A, fig. 328, the covers C, for which castings in brass, with the edging strips cast on, are recommended, being affixed as shown at B.

Saddles to carry smokeboxes and to cover-in steam pipes are advisable wherever they are possible, and can be made in a variety of ways according to the requirements of the design. One good method is shown by the several sketches in fig. 326.

Fig. 327.

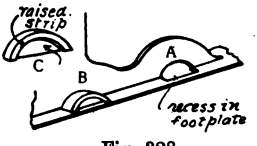


Fig. 328.

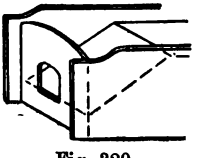


Fig. 329.

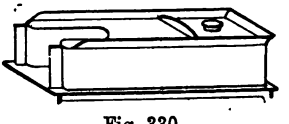


Fig. 330.

Tender Tops.

Fig. 327 shows a simple method of making the front portion of a typical leading front-coupled engine, a circular smokebox and cast door being used, and the latter made flush with the saddle.

When models are to be made in quantities, cast brass and aluminium may be employed for all portions of the superstructure, metal patterns of say No. 15 or 16 S.W.G. material being used, all

edgings, copings, window openings, etc., lugs, angles and ears for putting the parts together being incorporated in the patterns. Cab roofs can be cast flat and be bent to shape before fixing.

Many excellent models the writer has had the pleasure of viewing have been spoiled by the use of thick handrails. In actual practice 1⅛-in. tube is employed, and therefore steel wire for model handrails should be obtained of a gauge as nearly as possible a

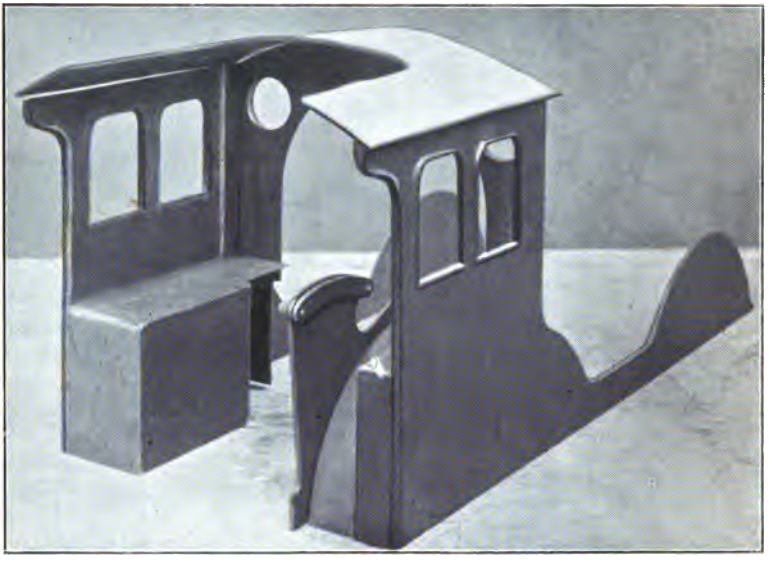


Fig. 331.—Cab and Splashers for a ¾-in. Scale Model.

scale reduction of this diameter. For 1-in. scale model No. 12, for ¾-in. No. 15, and for ⅝-in. scale No. 16 S.W.G. material should be used; other sizes in proportion to these.

Tenders.

The function of a locomotive tender is to carry the fuel and water required by the engine, and, as the name implies, a tender is quite a separate vehicle.

The standard British tender is a six-wheeled vehicle as shown in fig. 335, the total wheel-base, which is rigid, varying from about 11 ft. to 15 ft. in the G.W.R. example (fig. 332).

In the prototype the major part of the tender consists of a water tank, a well very often being sunk below the footplate level between the wheels for the whole length of the vehicle, to increase the storage capacity. On the top of the water tanks the coal (or other fuel) is stored. To render the shovelling of the coal into the firebox as easy as possible, the tank tops are arranged in various ways according to the designer's ideas. Several are illustrated by

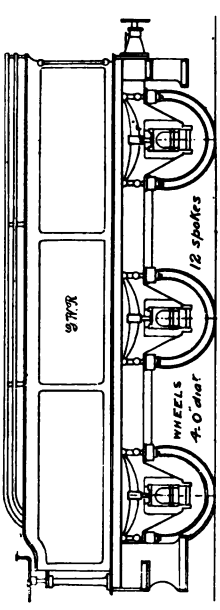


Fig. 332.

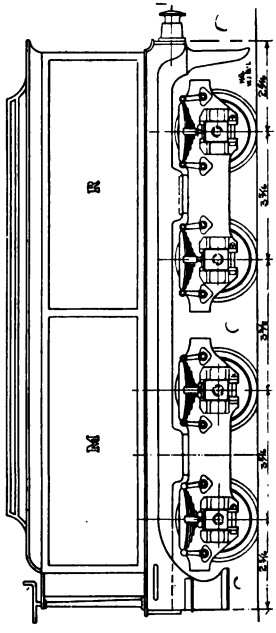


Fig. 333.

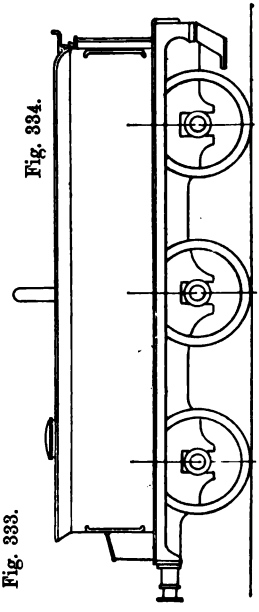


Fig. 334.

the accompanying diagrams, that shown in fig. 329 being one of the best for model purposes.

Most tenders have outside frames shaped as shown in fig. 335, a variation in the shape of the frames being the G.W.R. and L. & N.W.R. patterns. The latter type, in the original, has wooden frames with steel hornplates, attached to the inside of the sole bar. Sometimes, as on the L.B. & S.C.R., tenders are provided with inside frames only, as shown in fig. 334. On those railways not fitted with water troughs large tenders are necessary for long-distance runs, and it is now customary to support such vehicles on two four-wheeled bogies. Fig. 333 illustrates the

latest Midland tender, dimensioned for the $\frac{5}{8}$-in. scale model described in the Appendix.

A design for a $\frac{3}{4}$-in. scale double bogie tender is shown in Plate VII. The bogies, of course, do not require lateral play, being pivoted only. It will also be noted that the movements of the bogie are very limited, owing to the position of the compensating beams and bogie frames in respect to the main frames of the tender. For sharp curves the type of tender shown on page 233

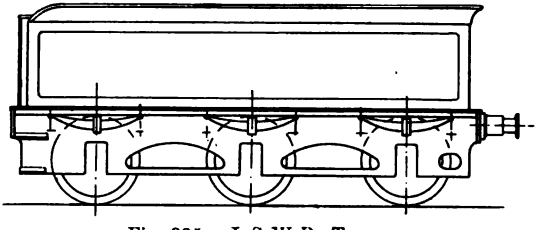


Fig. 335.—L.S.W.R. Tender.

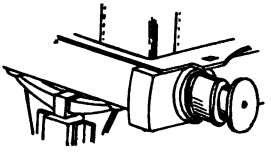


Fig. 336.—Rear Corner of a L.N.W.R. Standard Tender.

would be much better, as, by the use of small wheels and low bogie frames, the utmost freedom is obtained.

Inside-framed bogie tenders look very well in conjunction with inside-framed engines, and also may be very easily made, the work to the frames, springs, and axleboxes being simplified in the various ways already referred to in describing the construction of engine bogies.

Pumps and Injectors.

Hand pumps are to be recommended for replenishing the boilers of small models, although they are not so necessary where water-tube boilers of the 'Smithie' pattern are employed, as these generators hold sufficient water for a lengthy run.

A very good pattern is that shown in fig. 337. In this example the pump is 'drowned,' the suction-valve box needing no pipe, the passage being drilled through the casting and emerging at the base, which is filed away to allow the water to enter the passage. Sometimes it is not possible to adopt the above method, as the pump cannot be placed inside the water tank, and therefore a pipe will have to be carried from the suction valve-box to the main supply, or to the communicating pipe in the case of a side

tank engine, as indicated in Plates III., IV., and VIII. Where no water at all is carried by the engine or tender, a piece of flexible (indiarubber) tube of sufficient length to reach a tank placed beside the line may be fitted to the suction box, and when not in use this pipe may be coiled up in the tender or bunker.

Hand pumps may be placed in one of the side tanks if the bunker is used wholly for the fuel supply, or can be fixed at a convenient place on the railway and the delivery pipe attached by a screw union whenever the boiler requires replenishing.

The above type of pump should not be made with a ram larger than $\frac{3}{8}$-in. diameter, otherwise at high pressures it will be found difficult to force the ram down. Larger hand pumps should be fitted with a lever, as illustrated in fig. 339.

If the engine is desired to run a long time without attention, force pumps may be worked by means of an eccentric placed on the driving or coupled axle.

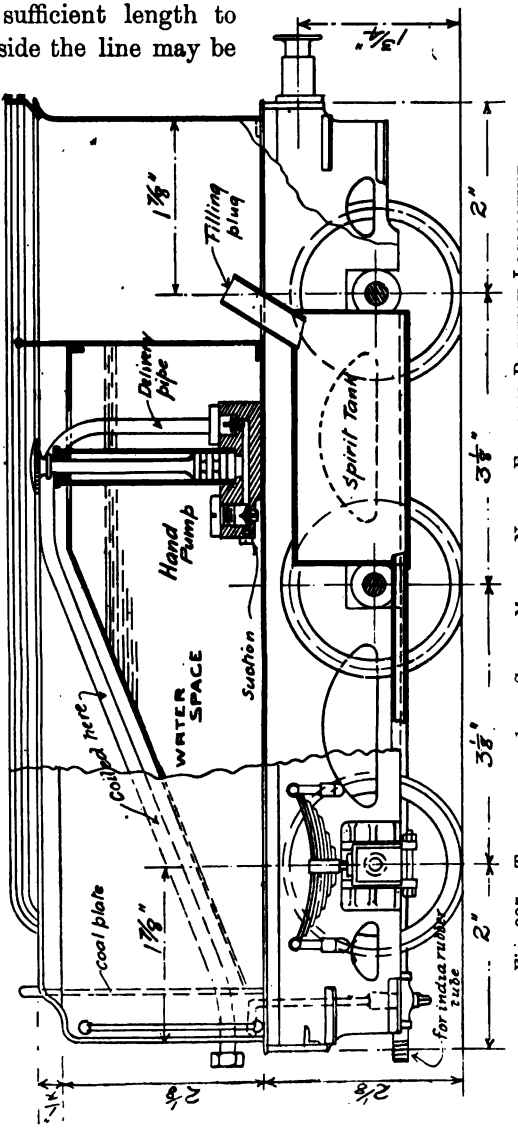


Fig. 337.—Tender for ½-in. Scale Model North-Eastern Railway Locomotive.

An arrangement suitable for a $\frac{3}{4}$ or $\frac{5}{8}$-in. scale model is shown in fig. 338. To ensure success it is necessary to design the pump to throw more water than is required by the boiler, turning some of it back into the tank. By this means the pump will always automatically re-start. Large engines sometimes have a very small hole drilled in the ram chamber communicating with the outer air

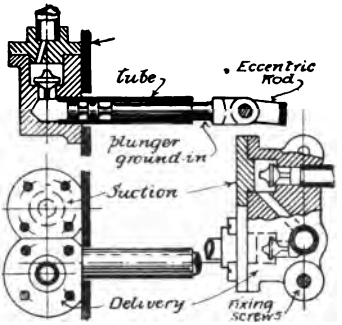


Fig. 338.—Automatic Pump.

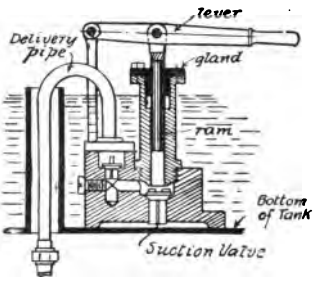


Fig. 339.—Lever Pump.

and forming a permanent pet-cock. This course may be employed in model practice. However, if a bye-pass cock is used as hinted above, and arranged so that it is not possible for it to be shut off and the amount of the opening capable of adjustment, the supply to the boiler may be regulated to a nicety.

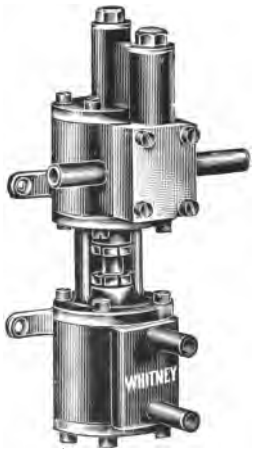


Fig. 340.—A Small Donkey Pump.

Pumps actuated from the crosshead are not to be recommended, and it should not be possible for communication to the boiler from the delivery of pumps operated by the engine to become closed, therefore clack valves of the pattern illustrated in fig. 313 are not suitable in such cases.

Donkey pumps may be employed for feeding the boilers of larger-sized locomotives, a suitable arrangement for a $10\frac{1}{2}$ or 15-in. gauge engine being one injector, a donkey-pump, and a hand-pump. Steam pumps, imitating the Westinghouse air-brake pumps, of a size suitable for a 1-in. scale

model, may now be procured. The makers state that these pumps work very well if they are not forced.

No engine of larger gauge than 6 in. should fail to be fitted with an injector, and the 'Vic' injectors, which are self-starting and can be obtained in very small sizes, are to be recommended. In ordering these fittings the working pressure should be given, as the maximum range of action of these injectors is about 30 lb. Great care should be taken to see that ample area is provided for the steam passage to the injector, and that the delivery pipes are of sufficient internal diameter and are conducted to the check valve—a good design for which, suitable for a 2-in. scale model and an M1 size of 'Vic' injector, is shown in fig. 313, page 225 — with as little change of direction as possible and without awkward bends and elbows. In no case should the delivery pipe and check-valve passages for the smallest injector be less than $\frac{3}{16}$-in. diameter.

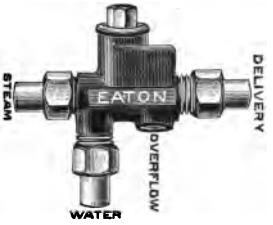


Fig. 341.—'Vic' Injector.

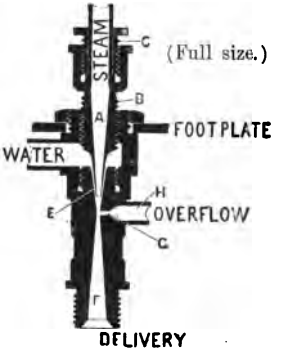


Fig. 342.—Mr. Henry Lea's Miniature Injector.

Mr. Henry Lea, M.I.C.E., who is an authority on the subject, describes the making and fitting of a miniature injector to his $\frac{3}{4}$-in. scale Midland locomotive in *The Model Engineer* for April and May 1900.

The first injector Mr. Lea fitted had a bore of ·022 in., and had the steam cone, the mixing cone, and the delivery cone all separately screwed into an outer body. It was found, however, that it was much better to make the mixing cone and the delivery cone in one piece of metal, the overflow holes being drilled transversely at the meeting of the two cones. The ·022 injector proved to be much too large, and another was made having a bore of ·018 in. This was more troublesome to get to work, but eventually success was attained. A is the steam cone pointed with a double thread at B for quick adjustment, and a union joint at C. E is the mixing

cone, and F the delivery cone, both contained in one piece of metal. There is only one overflow hole, G. H is the overflow pipe.

Mr. Lea found that whereas the ·022-in. injector would start, without adjusting the steam jet by simply turning on the steam, if not turned on too suddenly, the ·018 injector would not do so. Probably the extremely small size accounted for this. But he found that if a pet-cock on the delivery pipe were opened before starting, the ·018 injector would start well, without adjusting the steam jet, and upon closing the pet-cock the water would at once go into the boiler. He therefore made an automatic pet-cock or valve in which the valve, opening downwards by its own weight, afforded an escape for air, but as soon as the water reached it, it rose and closed the aperture. There is, therefore, now nothing to be done but to open the water valve in the tender, and to turn on the steam, and then to close the two valves when sufficient water has been sent into the boiler. The injector works well, without readjustment, from the safety valve pressure of 20 lb. per square inch, down to between 1 and 2 lb. per square inch, which is rather remarkable.

Fuel, Firing Arrangements, Brakes, and other Fittings.

Upon the fuel to be employed many important considerations in the design of a model locomotive depend. Whereas on, say, a ¾-in. scale engine charcoal may give excellent results, oil fuel may be found less suitable, and methylated spirit, burned in the ordinary wick lamp, utterly useless. The fuels from which we have generally to choose are as follows:—

Methylated Spirit (or spirit of wine), used in a wick lamp, or vaporised and burned in the same manner as coal gas.

Petroleum (lamp oil). This fuel may be consumed in a Swedish 'Primus' stove burner as first used in connection with model locomotives by Mr. H. E. Morriss, or in one of Mr. C. L. Palmer's steam Spray burners (see p. 243).

Charcoal, Coke, and Coal in ordinary deep sided fireboxes with the usual grate. "Union" coal briquettes make excellent fuel for larger engines, being smokeless and of high calorific value.

PATENT FUEL has been suggested by Mr. Palmer.

The latter is made for foot-warmers, and is said to be an ideal fuel for model steam engines. It is smokeless and nearly odorless, and under natural conditions burns slowly. A small piece once fairly ignited will burn to ashes without going out. It makes a little ash, like red sand, unlike the feathery ash of charcoal, which flies over everything. To use it, it should be broken up small, and thoroughly ignited before putting in firebox; it should then be urged by a bellows or blower. Under the blast of the exhaust it kindles to a fierce white heat. It burns without sparks or smoke, and when steam is shut off, will remain at a dull heat for hours. Mr. Palmer says that Messrs. Lehman Brothers, 10 Bond Street, New York City, supply the fuel for their foot-warmers.

For engines up to $\frac{3}{8}$-in. scale, whether provided with a loco-type or with a water-tube boiler, the best fuel is methylated spirit, consumed either in a wick lamp or by means of a vaporising burner. *Oil fuel* in a 'Primus' burner may be used in special instances.

Locomotives of $\frac{3}{4}$-in. scale with water tubes in the firebox and ample heating surface should be fired with *Petroleum* on the 'Primus' system, if the least trouble is desired. *Spray oil* burners may be used, but they require a little more attention.

Charcoal will be found a very good fuel if the boiler has insufficient heating surface and if the firebox is deep enough. A fire made up of this fuel will require constant replenishing, but the heat obtained is very much superior to that given out by a 'Primus' oil burner.

Models of 1-in. scale having water tubes in the firebox may be fired by *oil* in Primus burners with great success. Under other circumstances charcoal or coal, or charcoal, cinders and steam coal admixed, or "Union" compressed blocks, will be found satisfactory.

Larger engines, except those with water-tube boilers, having more than 30 square inches of great area and capable of being ridden upon, are best not fired with anything but Welsh *steam coal* or coal briquettes. Powerful *spray oil burners* may be employed in conjunction with a coal fire. The smaller sizes ($1\frac{1}{4}$ and $1\frac{1}{2}$-in. scales) may be fed with a little coke, charcoal, cinders, or other light fuel in addition to the coal, or briquettes alone.

Water tubes are not so essential in an engine consuming solid

fuel as in cases where methylated spirit lamps or Primus burners are used, but a deep grate is indispensable.

The author has, it will perhaps be thought, rather forcibly stated the case of the water-tube boiler for tinier models in previous chapters; and while their superiority is not at first apparent, it is the fuel (spirits) used in small locos that really decides the question. Methylated spirit may be used with success in, say, a ½-in. scale model with a loco-type boiler; but to ensure this it is necessary to make the firebox and tubes of very thin metal. Screwed-in tubes are therefore impossible, and other valuable accessories, such as flame-surrounded superheaters, cannot be so easily fitted. Water tubes in the firebox are necessary, as most of the work is done by the surfaces *in contact with the flame*, the methylated spirit wick lamp having the peculiarity of evolving more vapour than, in confined positions especially, it will consume. An ill-ventilated fire will burn quite blue, and it is not until the color of the flame has an orange tinge that anything approaching complete combustion is taking place. During the time that the engine is standing, choking will be very noticeable, and the smokebox and tubes will be found to be covered with beads of condensation, showing also that no useful work is being done at the end farthest from the firebox. The remedy is a good draught. One method of ventilating the fire of a small loco-type boiler having a big firebox and a comparatively large lamp is shown in fig. 344. When the engine is steam raising and is not running, the induced draught caused by the exhaust being inactive, the auxiliary flue should help matters considerably.

For the before-mentioned reasons, viz., the more or less local heat supplied by the methylated spirit flame, a Smithies' water-tube boiler has greater advantages in that the most efficient portion of the heating surface is in contact with the fire, and during steam raising the fire may be readily ventilated by opening the smokebox door. There are certain rules in making spirit lamps which, if observed, will tend to perfect success in the working of a model locomotive and lessen the liability of accident.

Wicks should not be placed too high or close together, but evenly distributed; see fig. 334 for example. The reservoir should be connected to the wick tubes by small pipes as shown in fig. 343

herewith. This will prevent the spirit boiling over. It should not be possible for the vent of the reservoir, which often emits inflammable vapour, to become lighted by the flame of the wicks, therefore it is always best to bring the vent above footplate level.

To stop any spirit which may have overflowed the wicks running along the conducting tubes and catching fire under the reservoir, a protecting plate, as depicted in the accompanying sketch, should intervene between the rear wicks and the reservoir. This not only forms a 'drip' for the spirit, but protects the tank from the radiant heat of the fire. Where plate is inadmissible, a small washer should be affixed to the pipes (see A, fig. 343).

The wick holders should vary from $\frac{3}{8}$-in. in diameter in small models to $\frac{9}{16}$-in. in larger engines, and may be best made by plugging the ends of pieces of brass with discs of metal—hard-soldered in place if possible—and drilling holes for $\frac{3}{16}$-in. brass conducting tubes. To allow the spirit to flow to the wick holders the conducting tubes should have two nicks filed in them at each holder. These tubes should be silver-soldered in, and the outer ends should be plugged.

The wicks should always be made of asbestos yarn, so that they will not burn away when the spirit runs out.

Should a small scale engine be so unfortunate as to have insufficient heating surface, and if flame-superheating does not give the desired success, then, to save the trouble and expense of a new boiler, the spirit may be vaporised in a separate container, and led to a 'Bunsen' burner. One arrangement—which is perhaps the best—is shown in the accompanying fig. 345. A steady draught should be maintained, otherwise the vapour will refuse to burn. A pilot light is also required, the reservoir of which may also supply the wick lamp for boiling the spirit.

The drawback to the arrangement is its complexity; two lamps need attention besides the burner itself, and the level of the spirit in the container must be watched as well as that of the water in the boiler.

Paraffin burned in the Swedish 'Primus' burners is an excellent fuel for model locomotives which have fireboxes wider than $2\frac{1}{8}$ in. (measured inside), and the best results are obtained where firebox water tubes are present; all the same, the products of combustion

have none of the objectionable features of those of methylated spirit. The flame temperature is certainly much higher in the former; and whilst an induced draught is indispensable (see p. 58), more complete combustion is obtained with less air. Flue tube surfaces therefore have greater evaporative value, and superheaters in the smokebox may be employed with advantage, as under ordinary circumstances the smokebox temperatures are sufficiently high to warrant their use in this position.

Swedish burners require ordinary lamp oil, vaporising it in the burner, the jet of gaseous petroleum being passed through a 'Bunsen' tube and emerging from a series of silencing holes on to the baffles, which complete the ignition of the gases. To give an impetus to the jet and to keep the burner full of oil, the tank is sealed and air is pumped in on top of the oil; the output of the burner depends on the pressure of air in the reservoir.

A 2½-in. (No. 4) Primus burner will consume about one-third of a pint of oil per hour, and therefore it will be seen that with paraffin at a penny per pint an inch-scale loco will not prove costly to run.

For small locomotives it is necessary to bend up the conducting tubes of the burners (this can be done easily in the vice) so that the union spigot stands at right angles to the vertical centre line of the burner. As the threads of the burners are not of standard English pitches, special reducing sockets must be made or else the pipe *silver-soldered* directly to the burner (see Plate V.). Soft solder cannot be relied on nearer than six inches to these burners, unless the joints are also screwed; for instance, the wheel valve shown in Plate IV. should be screwed to the tube, the solder acting as a caulking material only.

Soft soap smeared on unions and other packed joints will effectually make them oil-tight. It will also be found that great care is required in making joints for 'Primus' pipe work—old gasfittings are worthless in this connection. All swivel joints must have packed glands.

A very suitable burner arrangement is shown in Plate VIII., the burners being screwed into a rectangular section tube. The only improvement worth mentioning would be to provide a release valve near the burners to drain away the oil when the burners are not working (fig. 346). This is an important point, and to

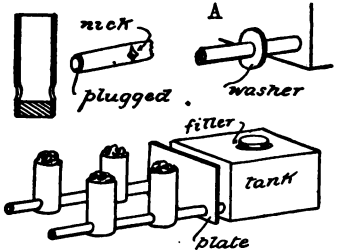


Fig. 343.—Spirit Lamps.

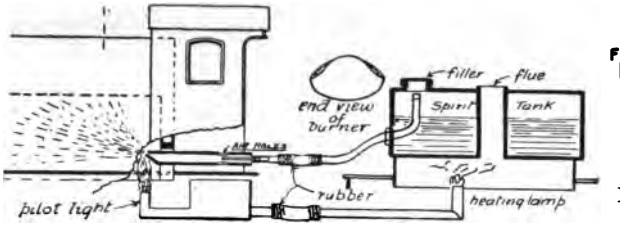


Fig. 345.—Vaporising Spirit Burner for Model Locos.

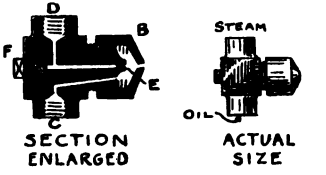


Fig. 347.—Spray Oil Burner.

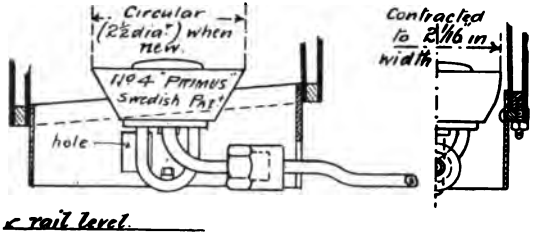


Fig. 348.—Oil Burner for a ¾-in. Scale Model.

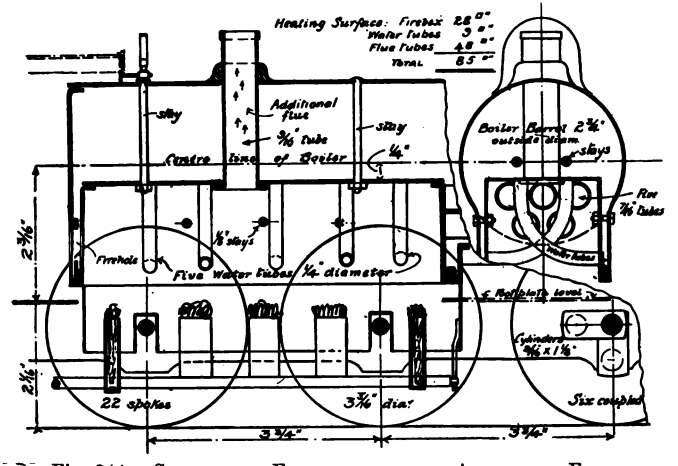


Fig. 344.—Section of Firebox showing Auxiliary Flue.

Fig. 346.—Drip Valve.

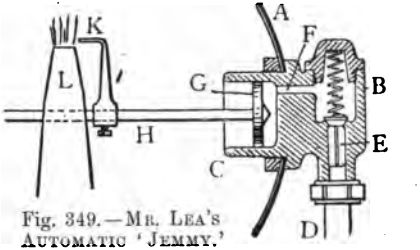


Fig. 349.—Mr. Lea's Automatic 'Jemmy.'

minimise the evil in the designs on Plates IV. and V. it will be noticed that the wheel valve is placed near to the burners; however, the drain valve is in some respects the better arrangement.

The flooding of the burner with oil whilst it is cold should always be prevented, as the impurities present in the fuel—although some of these may be kept out of the tank by straining the supply—often find their way into the nipple, and stop it up. Therefore, even if a drain valve is not used, a good screw-down wheel valve should regulate the passage of the oil to the burner. Another thing that may occur to make a burner fail is that the loose cap on top, which must be removable to allow of nozzles being taken out when occasion may require, may come off, and the burner

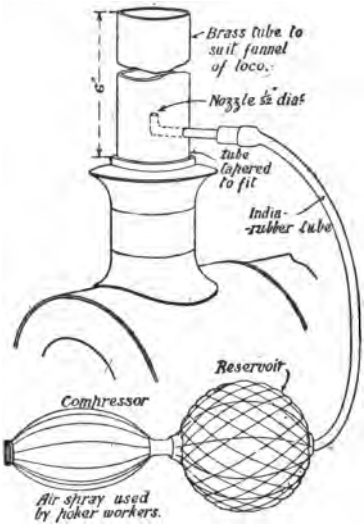


Fig. 350.—Auxiliary Blower for Steam Raising.

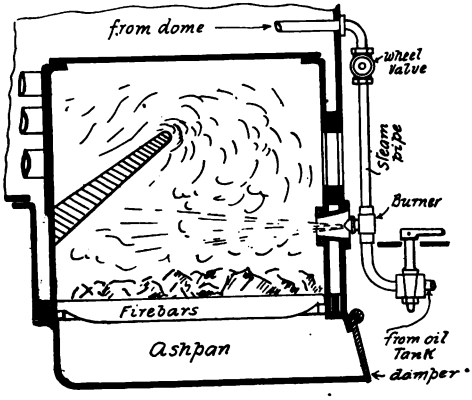


Fig. 351.—Spray Burner in Action.

smoke; so it is advisable not to remove the wire which is put on by the makers to prevent the cap being lost in transit; if it is removed it should be replaced, or other means taken to prevent the cap from falling away.

The method of starting a 'Primus' burner is simple. Having previously shut off oil-supply and filled tank with oil (about half-full), place under the burner a tin pan containing a dessert-spoonful of methylated spirit. Light this, and then insert in the chimney an auxiliary blower, shown in fig. 350, com-

mencing to work the latter, and to so keep the flame in an upward direction.

The manipulation of the air bellows should be relegated to an assistant whilst the nipple of the burner is being pricked out with one of the prickers provided with the burners. For this purpose the burner should be placed in its lowest position.[1] Then create an air pressure in the oil reservoir of about 5 lb. per square inch, and when the spirit is nearly consumed, gently turn on the oil supply. If the burner floods, it is not hot enough, and the working should be stopped. If it goes all right, but makes a surging noise, cut down the supply with the wheel valve until this noise ceases.

The auxiliary blower being worked the while, steam in a $\frac{3}{4}$-in. scale model should appear in four to five minutes without a particle of smoke having been made. As soon as 5 lb. or 10 lb. pressure is obtained the steam blower should be turned on and the air pressure in the tank augmented.

This system of firing may be embellished in a variety of ways, one of the most valuable being the provision of two tanks—one high and the other low-pressure—the burner being switched over as occasion may require. All that is necessary to accomplish this is an extra tank and wheel valve, the low-pressure tank being fitted with a release valve only.

The ordinary single tank should have a filler and a release valve, and if the regulation Primus pump is not attached, then the pump valve alone should be fitted, the top being altered to suit a standard bicycle inflator. A 'Lucas' cycle valve may be employed instead of the modified pump valve.

Where oil tanks are situate in the tender, flexible couplings are necessary, and indiarubber being out of the question, the method illustrated in the photo on page 250, and detailed in Plate VII., is to be recommended. The oil pipes need not be larger than $\frac{1}{8}$ in. outside on a $\frac{3}{4}$-in. scale engine, and $\frac{5}{32}$ in. for larger installations. If 'Primus' burners are employed in connection with a Smithies' boiler, the sides of the firebox should be protected with asbestos (see Plate III.). In larger examples the shell should be made as described on page 192, in two thicknesses.

[1] Some means of doing this must be provided; in tank engines the oil reservoir should not be fixed down to the footplates.

Spray burners are in principle really oil ejectors, and are dependent on the steam in the boiler. They will, the author understands, evaporate 10 lb. of water per lb. of oil, and 6 cub. in. per minute from 460 sq. ins. of heating surface.

The burner should be constructed accurately, as shown in fig. 347, with the hole in F perfectly centred in all positions with E. The hole E should be ·01 in., and the hole in cap B ·02 in. in diameter. The steam should enter at D, and the oil at C. The cap should be adjusted until the burner throws a fine, clean spray.

It should operate easily enough to work moderately by blowing with the mouth in the end of the steam pipe entering at D. It will lift oil an inch or more above the tank. If the tank has to be above burner, a cock must be placed on the supply pipe. This burner should blow into firebox at or below door, on to a grate covered with perforated tin, with broken soap stone above; a 'brick arch' of soap stone or firebrick may be employed with advantage. A coal fire may also be used for the purpose of igniting the flame. This burner requires a strong draught, or dense smoke and failure will result. To start the burner, compressed air is necessary until steam appears, and a bicycle inflator should be attached to a non-return valve fixed in the boiler.

The steaming of engines consuming solid fuel must be regulated in other ways than by the supply. The most useful method of checking the evaporation is by means of an enclosed ashpan having a 'damper' door, the opening and shutting of which alters the amount of air passing to the fire. The firehole door may be used in conjunction with the damper, but this should not be kept wide open when the blower is full on, or when the engine is working hard, as by doing so a considerable amount of cold air will get to the tubes and affect the tightness of the boiler.

If the fire is sluggish, then with the damper wide open and the firehole door quite close, it may be urged by the use of the blower. If the circumstances are opposite, the injector should be put on, the firedoor opened, damper closed, and the blower shut down to the minimum. To ensure the engine steaming, the flues should be swept at frequent intervals, and the smokebox door should be kept absolutely air-tight.

For steam-raising purposes an enlargement of the arrangement

illustrated in fig. 350 should be used, a footblower taking the place of the hand bellows. Instead of an extension stack a small pipe (about $\frac{1}{4}$ in. diameter for a 2-in. scale loco) may be inserted in the smokebox, the extremity turning upwards and acting as an auxiliary blower, the outer end being coupled by a flexible pipe to the foot blower. Do not in any case attempt to couple the foot blower to the boiler to work the steam blower by air. This arrangement has obvious drawbacks, and the steam blower orifices will, or should, if they are correct in the first place, be found much too small for the low pressures obtained by a foot bellows.

The most usual cause of failure in model locomotives where the design is good, is in the matter of smokebox arrangements and valve setting. Engines often fail through the valves being badly faced and allowing the steam to blow through to the exhaust. Where such a blow is present, it will also indicate that either the pistons are faulty and wanting new rings or packing, or else that the cylinder is not truly bored. Again, the valves may be rusted on the spindle, and be off their faces if the engine has not been worked for some time previously. An irregular beat shows that the valves require setting, and an engine with a wet sluggish puff should be provided with either a superheater, or a smaller blast nozzle, or perhaps both.

Inability to steam where the engine *has* been working all right generally suggests a leak in the boiler or in the steam connections, such a leak, however small and unnoticeable, interfering with the draught and reducing the evaporative power of the boiler.

For engines of $\frac{3}{4}$ and 1-in. scales upon which the owner cannot ride, elaborate systems of control from the line may be devised, and where such are not used and the line is laid alternatively with long straight runs and comparatively sharp curves together with steep inclines, some method of control is advisable. Throttle-valve governors are therefore suggested, these acting when a certain speed is reached.

To regulate the production of steam Mr. Henry Lea used an automatic 'jemmy' (see fig. 349) with great success. This fitting is worked by the steam, which at given pressure lessens the inductive action of the exhaust on the fire. Fixed to one side of the smoke-box is a valve-box B and cylinder C. Steam is led from the

boiler to the under side of valve E, which is held down by a spring of such a strength that it rises at just below blowing-off pressure and allows the steam to press on the piston G. This moves the arm I, on the top of which is a flat plate K, and baffles the jet, so that it is prevented from continuing to urge the fire. When the steam pressure falls, a spring (not shown) brings the baffle back again into its normal position.

Brakes and regulators may be actuated from the rails by roller levers working on inclined contacts, and steam may be shut off

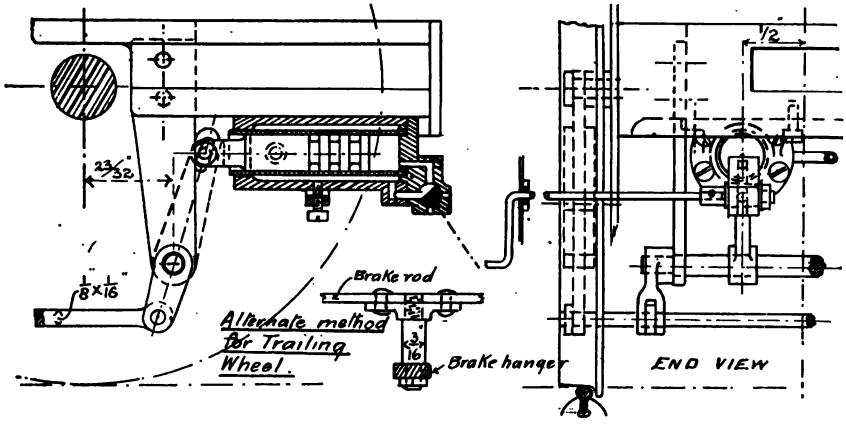


Fig. 352.—Steam Brake for a ¾-in. Scale Model.

over certain portions of the line and put on again by suitable devices too numerous to mention here.

Steam brakes are recommended for all engines of ¾-in. scales and above, and in larger engines are indispensable. The diameter of the ram should be about ⅝ of the diameter of the engine cylinders.

Fig. 352 shows a jacketed cylinder worked by a cock on the back cover. The screw on the under side of the jacket should be adjusted so that the leakage is just sufficient to keep the jacket free of water. The cock and passages should be arranged so that the supply is drawn from the jacket, which is in direct connection with the boiler, and also in such a way that the jacket may be drained. The sketch shows the handle placed outside the footplate and the inclined dotted line corresponding with its 'full on' position; the reverse inclination will release the brake. An

upward movement of the handle from that shown will clear the jacket of condensed water. The position of the ram lever should be vertical when the brake is full on.

The handle of the valve may be placed in the cab by reversing the position of the cylinder and levers, turning the former on its side, and extending the control handle upwards. Fig. 353 is a design for a brake for a 10¼-gauge locomotive in which the objectionable plug cock is not employed.

Brake hangers may be double or single, clasping the block or

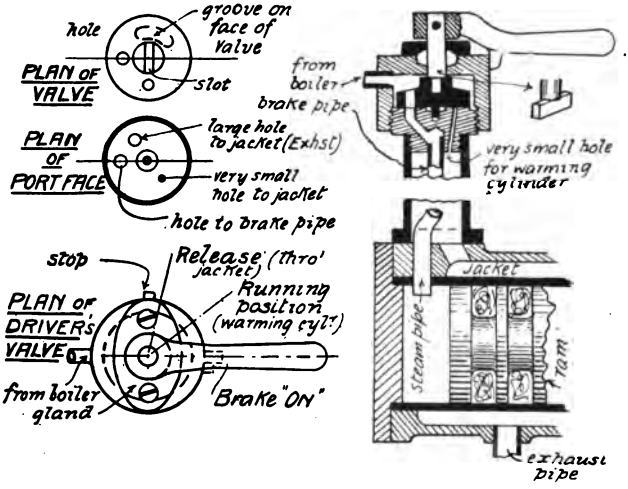


Fig. 353.—Steam Brake for a 10¼-in. Gauge Loco. (Half size.)

engaging a fork in the latter. The pressure on the blocks should be equalised for all wheels by means of suitable rigging. The photograph on page 265 shows one method. Here the rear cross bar is curved to clear the burner. The brake blocks should always be of softer material than the tyres. Brass filled with type metal may be used with success on large locos.

To thoroughly test a working model the best arrangement short of a continuous track is the use of the apparatus (devised by Mr. Henry Lea) illustrated in fig. 354. This arrangement of artificial load is a very good one. The writer has used a piece of apparatus in which the rollers are free and the load is applied by means of the hand brakes. Photograph fig. 370, page 275, depicts a 2-in.

scale model undergoing such a test but without rollers, the axlebox being fixed in the guides and the engine lifted and worked with the steam brake on. Free rollers may be employed for showing models working at exhibitions, compressed air or else an electromotor being the motive power.

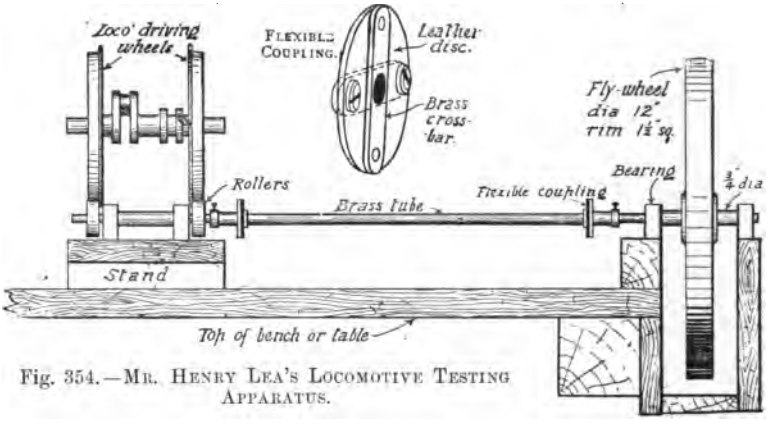


Fig. 354.—Mr. Henry Lea's Locomotive Testing Apparatus.

Roscoe displacement lubricators will be found the most convenient for miniature locomotive cylinders and valves, and may be fitted to the cylinder covers in inside-cylindered engines as illustrated in Plate III.

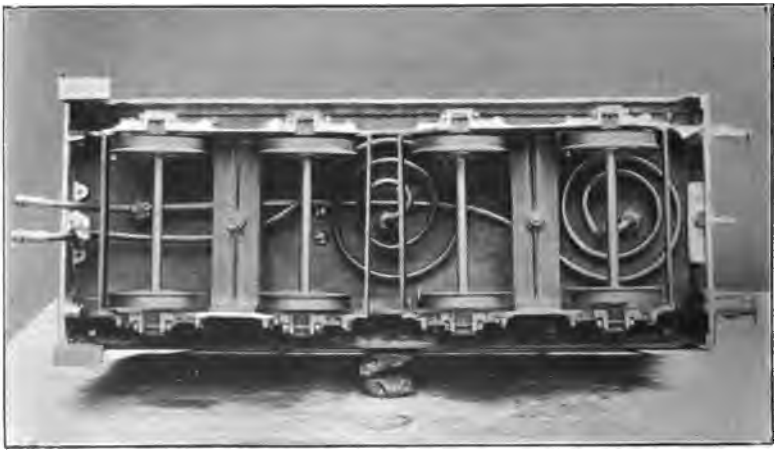


Fig. 355.—Connection of Water and Fuel Pipes from Tender.

DESIGNS FOR MINIATURE LOCOMOTIVES.

(See Folding Plates, Nos. II. to IX.)

A Simple Model Shunting Engine.

(*Gauge* 2½ *in.*)

Those who desire to build a model locomotive of the very simplest character for use on sharp curves cannot do better than adopt a four-wheeled shunting engine as a prototype. The only difficulty with such a locomotive is the provision of a firebox of ample dimensions. If it is placed behind the trailing wheel, it is necessarily limited. To overcome this difficulty, it will be noticed that in the design submitted herewith the whole of the propelling machinery is placed in front of the leading wheel—all the space behind the crank is then available for means of firing.

The boiler adopted is of the type described on page 54 (fig. 43). To assist in the matter of draught a separate vertical flue tube through the boiler from the furnace is advised, this being shown on the sectional elevation, the flue connecting with what appears to be a safety-valve column.

The boiler should be made from one piece of a solid drawn brass tube 2½ in. diameter, three turned brass castings serving for the back and front plates of the boiler and the smokebox front. At the smokebox a square hole must be cut in the under side of the tube to communicate with the horizontal flue.

The frames may be cut from brass or steel plate $\frac{1}{16}$ in. thick in two strips, 1¼ in. deep by 12⅜ in. long (finished size). The wheel-base of the engine is 4¼ in. equidistant from the ends. For the leading axle—springs not being used, because if such are employed in connection with oscillating cylinders the distribution of the steam will be interfered with—a plain ¼ in. hole is all that is needed for the axle. To lengthen the bearing, however, a brass axlebox should be screwed to the outside. The trailing wheels are fitted with spiral bearing springs (see fig. 64, page 75).

The cylinder illustrated in the general view is of the double-acting oscillating pattern already described in Chapter VII. It may be fitted with reversing gear as shown, when a regulator will not be

required, the three positions of the reverse lever in the cab, viz., forward, backward, and centre, sending the model either forwards or backwards or shutting off the steam from cylinders respectively.

Should objections be raised to the adoption of an oscillating cylinder, a slide-valve cylinder of the type illustrated by fig. 154 may be substituted. The drawings are more or less self-explanatory, and from a practical point of view there is not much to choose between the two arrangements as regards the running of the model. At the right-hand corner of fig. 154 is shown a diagram of the arrangement of the crank in relation to the 'side' rods. The crank pins for the coupling or 'side' rods *must be at* 90° apart; therefore, to preserve the best balance it seems preferable to place the crank at 135° from each.

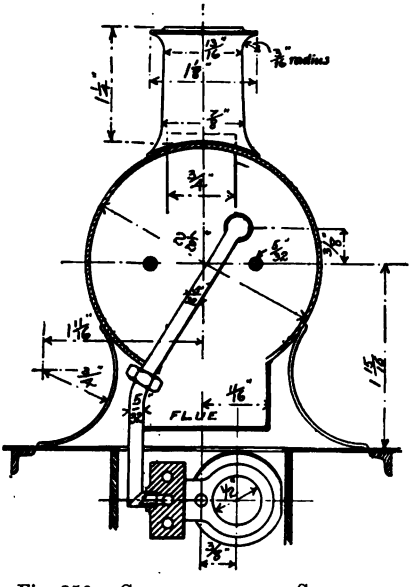


Fig. 356.—Cross-section of Shunting Locomotive.

A downcomer of either of the patterns described in Chapter X. may be used, preferably the cast one, as then no back-plate will be required. It should be attached by $\frac{1}{8}$-in. brass screws at $\frac{1}{2}$-in. pitch, five $\frac{3}{16}$-in. holes in the barrel connecting its water space to that of the boiler.

The tanks and cab are relatively simple matters. The former are dummy structures, and do not hold water; in this case they present an advantage, in that they can be filled with asbestos cotton, and so prevent radiation over a good proportion of the surface of the boiler. They also provide a protection against burning the fingers when manipulating the model, as they are disconnected to a great extent from the hotter parts of the engine. The sides and ends of the side tanks are of one piece; a top plate may or may not be fitted, as the maker decides. To protect the trailing wheels from the asbestos cotton, a splasher of tin plate

should be provided. The weather board of the cab should come nearly to the level of the foot plating in the inside of the tanks, and

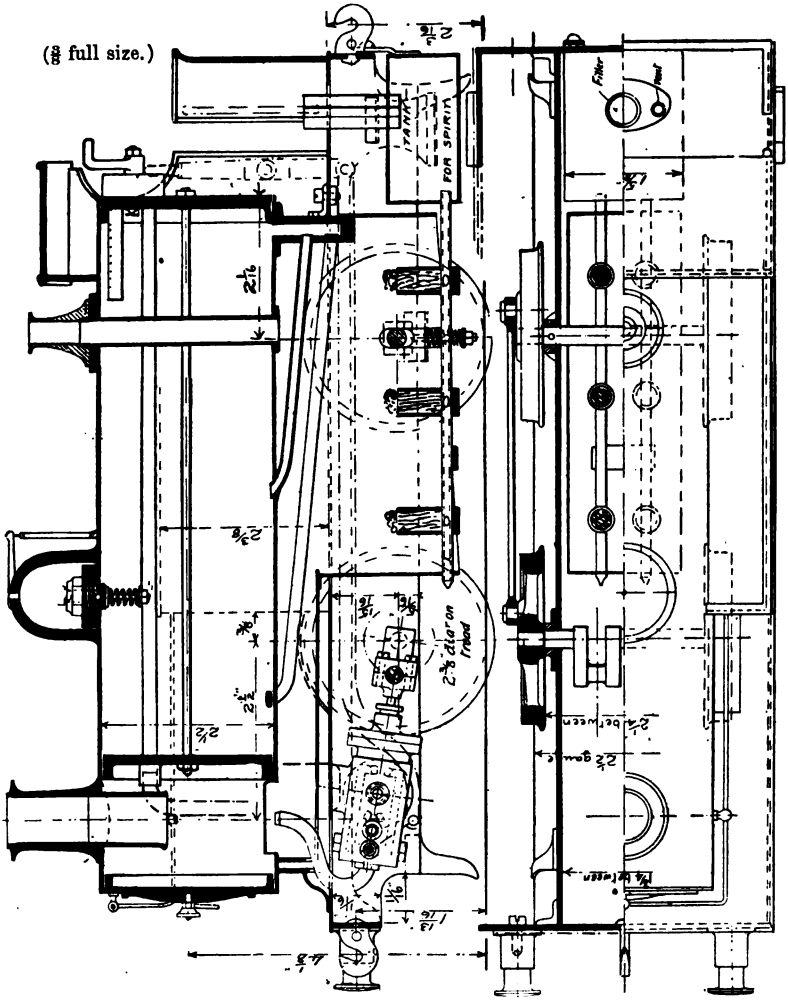


Fig. 357.—A Design for a 2½-in. Gauge Model Shunting Locomotive.

should be so shaped that the whole will slide on to the boiler from the rear.

The regulator, a detail of which will be found on page 222, may be placed on the back end of the boiler. The cab view of the model is shown on page 215.

The spirit tank should be made of tin-plate, and measures $1\frac{5}{8}$-in. $\times 2\frac{1}{2}$ in. $\times \frac{3}{4}$-in. At the back two strips projecting upwards should be soldered on. The strips should have a hole shaped like an inverted keyhole cut in them, so that each may be able to pass over the head of a slightly projecting round-headed screw fitted into the rear buffer plank. The weight of the lamp will cause the shank of the screw to engage the slot of the keyhole, when the head of the screw will keep the lamp securely in its required position. The front of the lamp is supported by the parts of the conducting pipes passing through the throat plating, which should be extended sufficiently low to allow this to be done.

A Model Single-cylinder Tank Locomotive.

($\frac{5}{8}$-in. scale and $3\frac{1}{4}$-in. gauge.)

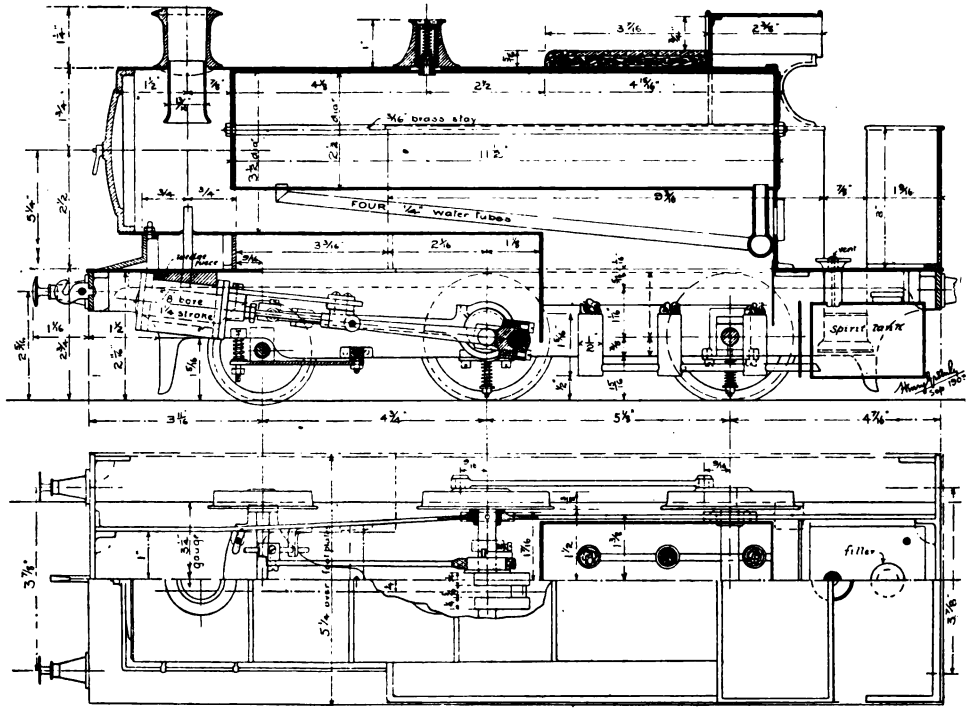
A model made to this design should steam very well indeed, and, due to the short total wheel-base and the presence of the pony truck, traverse sharp curves with the greatest of ease.

A single cylinder is intended, although the model may be fitted with two cylinders, as shown in Plate III. The kind of cylinder sold for model horizontal steam engines may be employed, a wedge-shaped piece of metal, to give the cylinder the required inclination, intervening between it and the footplating as shown in the detail (fig. 358). The footplating at the end as far as the side tanks—which, by the way, are imitation and do not hold water—should be of one piece to allow of this. The frames, if castings are obtained, should be screwed to the footplates by the lugs provided, the necessary setting-in to allow of the swinging of the pony truck being given to them previously, the castings being flat.

The horns are shown cast solid with the frame plates, and after the axleboxes have been fitted, vertical holes may be drilled and tapped to receive the hornstays, which should be flat strips of metal about $\frac{1}{4}$ in. $\times \frac{1}{16}$ in. and $1\frac{1}{8}$ in. long.

The boiler is of the Smithie's type, with a ⊥ downcomer, and to imitate the prototype has a dummy Belpaire firebox casing This fitting is useful in that it preserves the paint at the hottest portion of the boiler and prevents excessive radiation.

The driving wheels are $2\frac{5}{8}$ in. diameter and the leading wheels



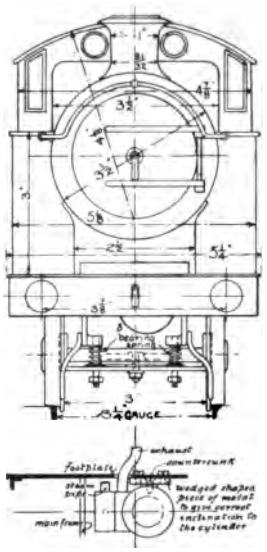


Fig. 358. — A §-IN. SCALE MODEL GREAT WESTERN RAILWAY TANK LOCOMOTIVE. (Quarter full size.)

2⅛ in. The spring buffers may be arranged as shown in fig. 91, page 88. If two cylinders are employed, five water tubes should be employed. The saddle in the example shown in the photograph is made by fixing the front and the back castings to the footplates and attaching the sides, which are made of thin plate, by countersunk screws. The front plate of the saddle should contain a stud for fixing down the boiler as indicated. The valve spindle should be supported by a guide as shown in the plan, the eccentric rod being pivoted to a movable block on the spindle, a set-screw holding this block in its proper position.

A Model North-Eastern Locomotive. (Plate II.)

(Scale, ½ in. to the foot; gauge, 2½ in.)

A further step towards the construction of the more pretentious 'scale' model is depicted to a scale of half full size in Plate II. The design is for a model of the North-Eastern Railway 'Smith' compound locomotive No. 1619; to provide a simple reliable working model, two cylinders only are advised. These are of the stock pattern already referred to in describing the design fig. 358, and are attached to the main frames by a casing which completely encloses the cylinders, as the $\frac{7}{16} \times 1$ in. cylinder usually procurable has covers of very small diameter and cannot be used as they stand without altering the 'scale' appearance of the model.

The covers of the cylinders should be fitted with countersunk screws to clear the casing ends, which may with advantage be discs of thin brass, nickel-plated to represent the polished steel cylinder caps of the original engine. The details (fig. 359) also show how the slide bars may be fitted to the circular stuffing-box of the ordinary pattern cylinder, the rear end of the bars being silver-soldered to a collar which should be bored to fit the stuffing-box.

To couple the eccentric rods to the valve spindle, holes in the main frames are necessary, as shown by the frame drawings on the Plate. The frames should be split horizontally at front ends, the lower portions being set in to give a greater amount of lateral play to the bogie.

The bogie is detailed in fig. 77, page 81, and the safety valve

regulator and boiler are respectively described on pages 210 and 190. The tender is illustrated by fig. 337, page 235, the spirit-tank being coupled to the lamp by an indiarubber tube, the supply being controlled by a cock.

A Model Front-coupled Tank Locomotive. (Plate III.)

(*Scale*, $\frac{5}{8}$-*in.*; *gauge* $3\frac{1}{4}$ *in.*)

The design for a $3\frac{1}{4}$-in. gauge model locomotive given on Plate III. will not, perhaps, satisfy the requirements of all, but as there exists a very large majority who find engines of scales upwards of $\frac{3}{4}$-in. much too large, such a model should be popular in more ways than one.

The gauge ($3\frac{1}{4}$ in.) is a trifle wider than the corresponding equivalent of $\frac{5}{8}$-in. scale, and taking the distance between tyres, it will be found that the excess of width amounts to about $\frac{7}{32}$ in.

A careful study of the drawings will show that there should be no difficulty in arranging for the model to fit a $3\frac{1}{16}$-in. gauge,[1] placing the cylinder axes $\frac{7}{8}$-in. apart, the frames and wheels, of course, being closed in to the exact amount of the reduction in gauge, $\frac{1}{32}$ in. being taken from the width of each of the eccentric sheaves.

The heating surface of the boiler is about 75 sq. in., calculating only half the area of the inner barrel and the whole of the water tubes. A separate wrapper is shown for the smokebox. This may be made out of steel, but, however, is not obligatory, and the outer shell of the barrel may be extended to form the smokebox, the boiler bands alone distinguishing the smokebox from the barrel.

Being a front-coupled locomotive, the engine not only lends itself to the provision of a large barrel and *long* firebox, but by placing the latter behind the driving wheels and over the main frames, an inner box $2\frac{1}{2}$ in. wide and $4\frac{5}{8}$ in. long (that is, $\frac{3}{16}$ in. wider and $\frac{1}{8}$ in. longer than the $\frac{3}{4}$-in. scale Caledonian design (see Plate VII.). This allows a $2\frac{1}{2}$-in. 'Primus' burner to be employed with the greatest of ease, and with little pinching in. The wide straight-sided firebox shown should be easy to make, and at the

[1] The correct scale gauge, taking the model equivalent for the all-important distance between tyres, which works out at $2\frac{13}{16}$ in., as the ruling dimension.

same time with, for a $\frac{5}{8}$-in. scale model, the comparatively large heating surface of 124 sq. in., it is not necessary to encroach on

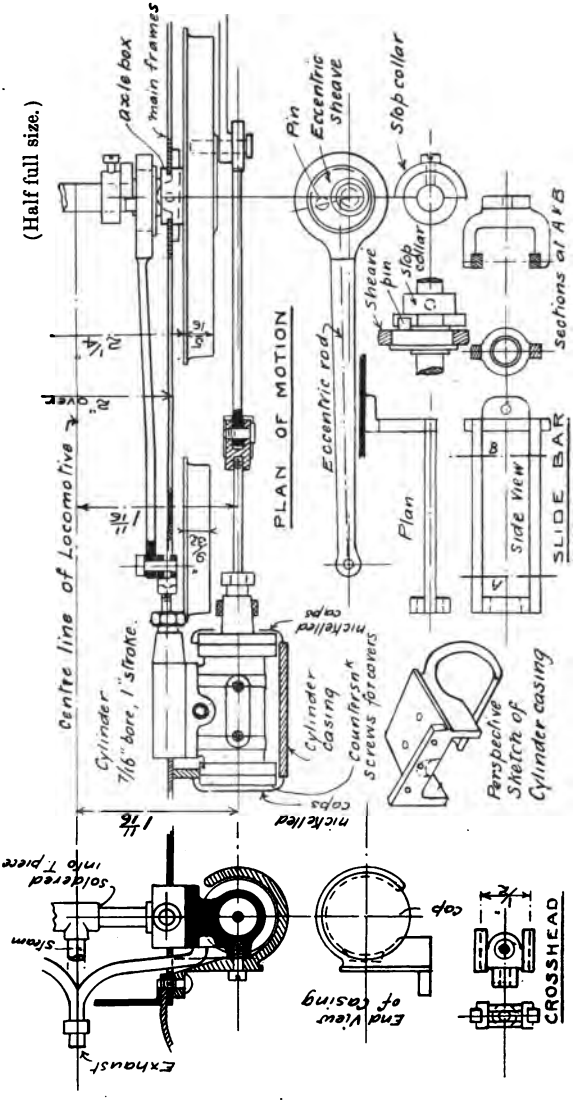


Fig. 359.—Details of Cylinders and Motion for Model North-Eastern Railway Loco. (See Plate II.)

the water and steam spaces of the barrel to an undue extent. Indeed, the crown of the firebox may be at least $\frac{1}{4}$ in. below the

centre line of the boiler barrel without cramping the tubes (see fig. 360).

The cylinders of the model (see full-size drawings in Chapter VII.) are $\frac{5}{8}$-in. by $1\frac{1}{4}$-in., slip eccentrics of a simple pattern being employed, the sheaves being steel, and the straps and rods of gun-metal cast in one piece, and attached to a rocker actuating the valves above the cylinders.

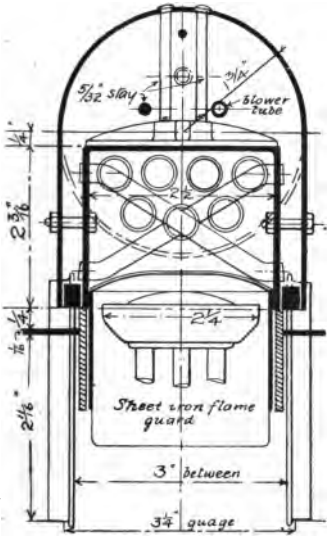


Fig. 360.

The main frames are of the simplest character and have no hornblocks, the extra thickness of the material making up for these fittings. The bogie is worked out on the principle described by fig. 72, page 79.

The main spirit tank occupies rather more than half the back bunker and feeds a supplementary tank of cylindrical shape placed under the footplates behind the bogie.

A force pump may be located in the left-hand portion of the bunker, the suction of which should be connected to the cross connecting pipe of the tanks, and the delivery pipe to the clack valve on the back of the boiler.

The cab should be entirely separate from the side tanks and bunker, and should have a hole in the roof with a cover which may be taken off during the running of the engine. If a double dome is employed (see fig. 285, page 212), then the pattern of regulator illustrated in fig. 309, page 223, and on page 203, may be employed, the handle in the cab remaining as shown on the Plate.

A Model Midland Locomotive. (Plate III.)

(Scale, $\frac{5}{8}$ in.; gauge, $3\frac{1}{4}$ in.)

The drawings, figs. 333, 361, and on Plate III., represent a model Midland Railway four-coupled express engine, the prototype

of which is a three-cylinder 'Smith' compound. The locomotive, however, is intended to work as a simple engine, and with two outside $\frac{5}{8} \times 1\frac{1}{4}$-in. cylinders (see figs. 139 and 140), slip eccentrics and a water-tube boiler, it will be found an excellent working model. The tender has a double bogie, and holds the water and spirit sup-

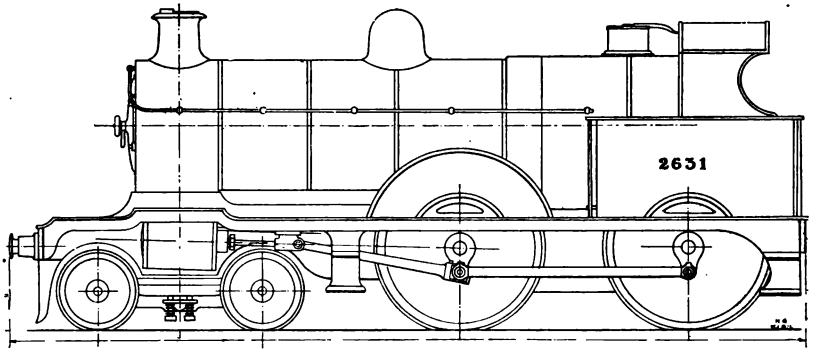


Fig. 361.—MODEL MIDLAND LOCOMOTIVE. (One-fifth size of model.)

plied. Seven or five water tubes may be employed. This model may be made completely of castings, and can be very quickly built up.

A MODEL SINGLE-WHEELED EXPRESS LOCOMOTIVE. (Plate III.)

(*Scale*, $\frac{5}{8}$ *in.*; *gauge*, $3\frac{1}{4}$ *in.*)

By reason of the increased gauge over and above the scale equivalent, a $\frac{5}{8}$-in. scale single-wheeled locomotive may be built

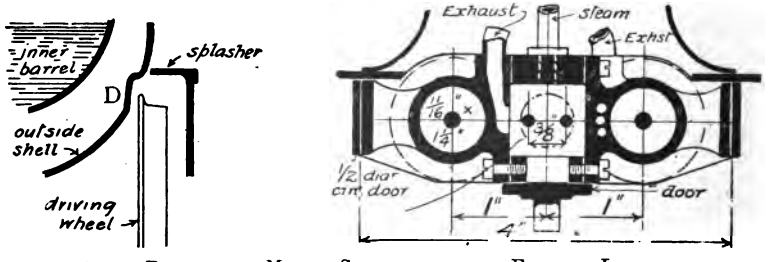


Fig. 362.—DETAILS OF MODEL SINGLE-WHEELED EXPRESS LOCOMOTIVE.

with a fairly large-sized wheel. In conjunction with a Smithies' boiler, the wheel may be as big as $4\frac{1}{2}$ in. with a $3\frac{1}{4}$-in. outer shell,

the latter being cut away at the driving wheel or dented in as shown at D in fig. 362.

The design submitted herewith may be fitted with cylinders of the same pattern as those shown on page 120, and as inside framing, except that at the smokebox, which should be used for sake of appearance and need not extend below footplate level, may be dispensed with, the cylinder centres may be placed much farther apart, allowing more room for the eccentrics and valve motion and a much larger steam-chest.

A Model of a Heavy Passenger Tank Loco.

(*Scale*, $\frac{5}{8}$ *in.*; *gauge*, $3\frac{1}{4}$ *in.*)

This design (Plate VI.) may, in its main details, be the same as that on Plate III., the outside framing allowing more room on the cranked axle for the use of link motion of workable dimensions (see fig. 363). The firebox is designed to be extended over the wheels as in the boiler on page 259, and a Belpaire firebox may be fitted with advantage. The dome may be arranged as illustrated in fig. 256, and the steam taken from the top of the Belpaire firebox (see fig. 268.)

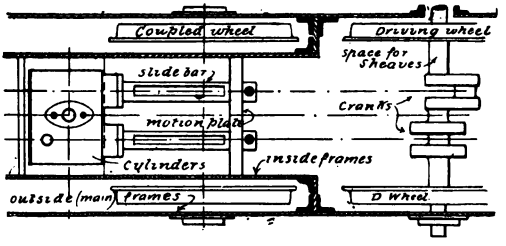


Fig. 363.—Plan of Motion for Model $\frac{5}{8}$-in. Scale Heavy Tank Locomotive.

A Model L. & N.W.R. Ten-wheeled Tank Locomotive.

(Plates IV. and IX.)

(*Scale*, $\frac{3}{4}$*-in.*; *gauge*, $3\frac{1}{2}$ *in.*)

This design is based upon that of the rebuilt L. & N.W.R. 'Metropolitan' tank locomotives, a class of engine which ranks amongst the handsomest tank engines now running on the L. & N.W.R.

The model is of the simplest construction possible for a $\frac{3}{4}$-in. scale locomotive which is intended to be an efficient working steam

engine. The larger diameter of boiler barrel obtainable by the omission of the lagging, whilst in some degree creating losses by radiation, allows more tubes to be used without reducing the steam and water spaces above the crown of the firebox, and, together with better steam distribution, due to the adoption of the single eccentric gear, renders the model, as a whole, not less successful than a more elaborate engine having all the refinements of modern locomotive practice.

A point of interest in the design is the use of one piece of 4-in. solid drawn tube for firebox shell, boiler barrel and smokebox. The outside firebox is a casting (with foundation ring), and is riveted over a hole in the under side of the barrel, the back end smokebox front and front tube plates being turned flanged castings.

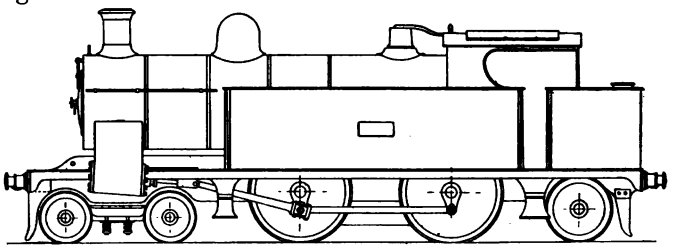


Fig. 364.—A Model London and North-Western Ten-wheeled Tank.

The 'field' tubes, which are five in number, and half inch in diameter, are screwed into the crown, and cross one another, as shown in dotted lines, an alternative system of firebox water tubes being indicated on the drawings.

The boiler is provided with two longitudinal stays, both of which serve other purposes—one being the blower tube, and the second the steam pipe which emerges from the regulator box on the backplate. The back end of the boiler being a turned gun-metal casting, has the advantage of providing plenty of metal for affixing the boiler fittings, which may be screwed into the back plate without the use of collars.

Steam is collected by a long pipe having twenty holes (or thereabouts) $\frac{1}{32}$ in. in diameter drilled in its upper surface, the dome being merely an ornament.

There is, however, no objection to a more orthodox arrangement

if the maker will go to the necessary trouble. To further ensure the delivery of perfectly dry steam to the engine—even at the expense of reduced pressure in the cylinder due to the throttling of the steam—a coiled superheater is intended.

The smokebox front is intended to be a solid iron casting with a dummy door and hinges, and should require no machining except on the flange, if cleanly cast, the strip round the edge of the door and the hinge straps being polished bright. The chimney, dome, and safety valve are brass castings.

The cylinders are $\frac{13}{16}$ in. in diameter and have $1\frac{1}{2}$-in. stroke, and are screwed to a connector steam chest with four $\frac{1}{8}$-in. screws, thus having a circular hole of the largest size possible cut in it on the bottom side. The circular door forms the bearing for the bogie, and is attached to the steam chest by six $\frac{1}{8}$-in. screws.

Into the circular steam-chest a stud is fixed, and as the cylinders are inclined the centre pop for drilling for this stud must be marked about $\frac{1}{16}$ in. behind the centre of the boss on the cover, so that the centre line of the bogie will be directly under the centre line of the chimney (see page 78). This boss must also be filed parallel with the rails, and should be flush with the bottom edge of the steel framing. The stud also should be driven in truly vertical, and not at right angles to the centre line of the motion. A detail of the radial truck at the rear end of the locomotive will be found on page 85 (fig. 83).

A Model Caledonian Railway Locomotive. (Plate VII.)

(*Scale*, $\frac{3}{4}$ *in.*; *gauge*, $3\frac{1}{2}$ *in.*)

This design, for a miniature of Mr J. F. M'Intosh's third and largest class of 'Dunalastair' locomotive, should satisfy the model-maker who desires to show his skill in workmanship, and at the same time wishes to be possessed of a reliable working model locomotive of moderate size, built closely to scale. As mentioned in the first chapter, the $\frac{3}{4}$-in. scale locomotive is rather a big engine, requiring curves of comparatively large radius (18 to 20 ft. in the model in question), and although such a locomotive can be made to pull one person easily, it is hardly one which would be chosen for this purpose. The design in the major part is from the pen

of Mr E. L. Pearce, the author being responsible for some of the engine details and the arrangement of the tender.

The gauge may be laid $3\frac{2}{16}$ in. where the railway is out of doors. The engine very closely conforms to the prototype, the most important deviation in the machinery portion being in the diameter of the cylinders.

By reducing the diameter of cylinders to $1\frac{3}{8}$ in., it is possible to get them together with the slide-valves comfortably between the frames, and the relatively small diameter will be compensated for by carrying a boiler pressure of 50 lb. per square inch.

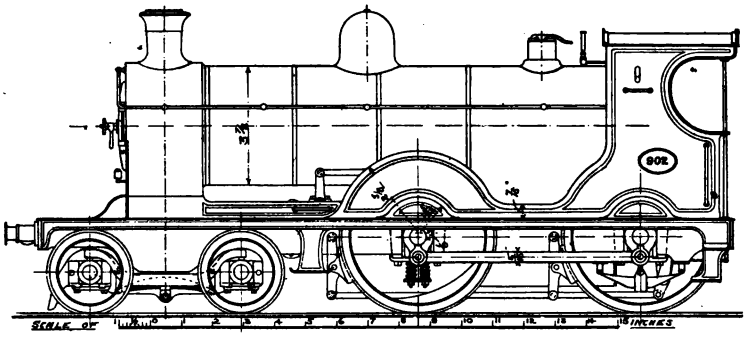


Fig. 365.—A MODEL $\frac{3}{4}$-IN. SCALE CALEDONIAN RAILWAY LOCOMOTIVE.

The frames, axleboxes, and other details are described in Chapter V., the cylinders in Chapter VII., and the crank axle by figs. 118 and 119.

The boiler is provided with a deep firebox, but as oil fuel is intended, it may be shallower and have water tubes in the firebox, as shown in Plate IV. or in Plate V.

A MODEL G.N.R. 'ATLANTIC.' (Plates V., VI., and IX.)

(Scale, $\frac{3}{4}$-in.; gauge, $3\frac{1}{2}$ in.)

To obtain a powerful working model with the exterior to scale in its main dimensions it is almost invariably necessary to fix upon a prototype of ample size. In Plate V. this has been accomplished, the engine chosen being one of the latest G.N.R. ten-wheelers, having a 'Wootten' firebox and a very large boiler barrel.

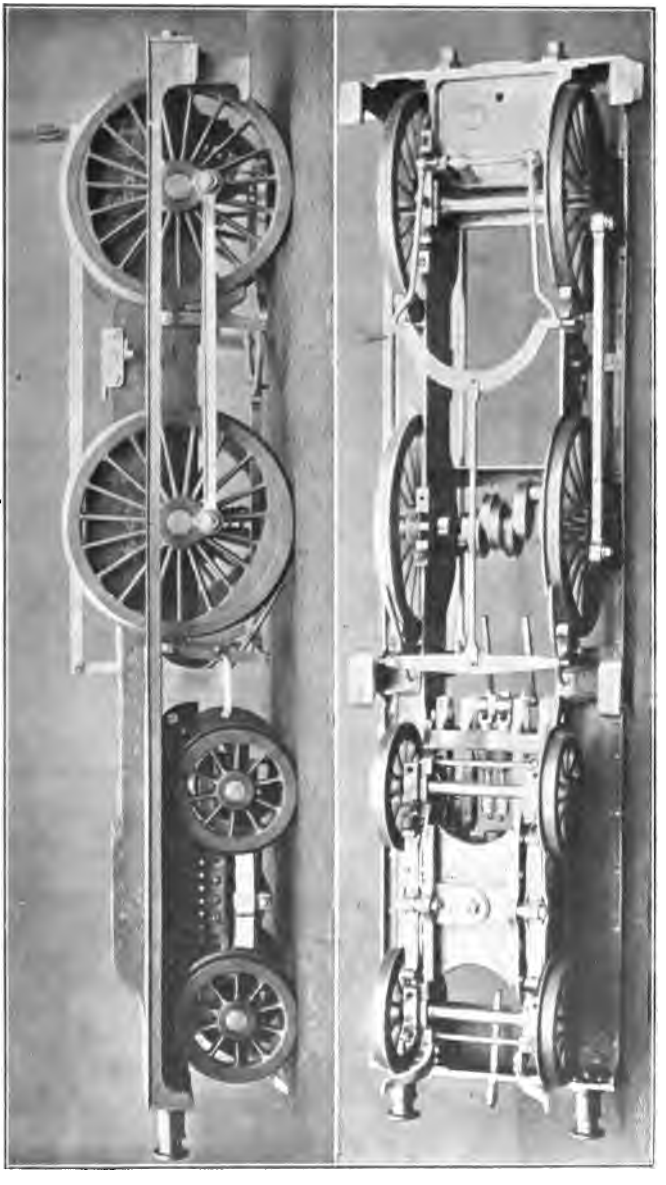


Fig. 366.—A Partly Finished ¾-in. Scale Model Caledonian Railway Locomotive.
Made by Mr W. H. Dearden.

The cylinders are $1 \times 1\frac{1}{2}$-in., the usual diameter for a $\frac{3}{4}$-in. scale engine being $\frac{3}{4}$ to $\frac{7}{8}$ in. The bogie wheels are slightly smaller than scale to allow them to pass under the frames when the engine is on a curve; but where this is not a point to be considered, the wheels may be larger, as in the original.

With the top row of tubes omitted and the firebox crown lowered over $\frac{1}{2}$ in., the cylinders being reduced in diameter to $\frac{15}{16}$ or $\frac{7}{8}$, a perfectly free steaming engine having a large range of water will be the result. The heating surface will be still large[1] compared with ordinary model locomotives of this size, and *where the superheater is* employed the 1-in. diameter cylinders may be retained,[2] the maintained steam pressure falling in proportion to the reduction of the heating surface. As will be seen by the drawings, the cylinders are of the pattern described on page 124, Chapter VII., the steam chest being provided with a circular door or cover on the under side, this cover carrying the bogie (see page 78).

The main framing of the engine stops at the firebox and is continued outside the trailing wheel of the locomotive, thus allowing the maximum room for the burner. Instead of using a casting for this frame, the laminated spring being a dummy and included in the one piece of metal, an alternative method of construction may be adopted, using sheet material throughout (see Plate V.).

The eccentric rods are long, and must be curved to clear the axle of the coupled wheel as shown in the plate. The intermediate valve spindle is supported by the motion plate, and to allow of the two enlarged ends, should be made in two pieces screwed together as shown in the plan. Another method of accomplishing the same object would be to enlarge the circular part of the spindle where it runs in the guide to $\frac{11}{32}$ or $\frac{3}{8}$-in. diameter, lengthening the guide also, and forming the forked end out of the circular section.

As the prototype is provided with a complex reversing gear and the wide firebox renders the ordinary arrangement of reversing lever difficult, therefore the simple method shown on the drawings was adopted, and instead of a notched quadrant in the cab, a slot link with a set-wheel locking arrangement devised. The

[1] About 310 sq. in. of heating surface.

[2] Otherwise $\frac{7}{8}$-in. cylinders would be advisable.

reversing arm of the weight-shaft being between the main frames and the tyre of the front-coupled wheel, a width of $\frac{3}{16}$ in. only being available for the joint of the reversing rod and the weigh-arm, a curved slot should be cut out of the main side sheet on the right-hand side (see sketch on Plate V.) to make room for this joint. The design having been prepared with an eye to the cost of the model, the dome is merely an ornament, and the regulator of a simple pattern.

The best course with the higher firebox crown would be to use a proper double dome and either of the regulator patterns described figs. 304 and 305 on page 223.

The superheater is of the 'hairpin' type, and allows great flexibility of the pipes in the smokebox, as well as little loss by the friction of the steam in its passage to the cylinders.

The smokebox front may be cast in iron in one piece and arranged to be readily removable. The firebox may be fitted with cross water tubes as shown, or with 'Field' tubes as in other designs.

A Model 'Fairlie' Engine. (Plate VIII.)

(*Gauge*, $3\frac{1}{2}$ *in.*)

To suit a model railway with heavy gradients and sharp curves, Mr R. W. Wright of Norwich some time ago suggested to the writer the building of a double bogie 'Fairlie' engine. Therefore the design Plate VIII. is submitted as a worked-out example. A powerful model should be obtained, and curves of 9 or 10 ft. radius for a $\frac{3}{4}$-in. scale loco quite easily traversed. With the wide firebox the use of two burners may be accomplished, and an auxiliary flue very simply arranged. One of the side tanks may contain the fuel (paraffin oil), and the others the water. The two boiler barrels should be connected by a single firebox, and all the fittings arranged at the side of the latter. Four $\frac{9}{16} \times 1\frac{1}{4}$ in. cylinders are suggested. The steam pipes should be of flexible metallic tubing, and the exhaust pipes should be similarly connected up, the end of the flexible tube being made of plain tube sliding in the blast pipe. The footplates should be made to take a part in the construction of the frames.

A Model of a Large Ten-wheeled Tank Locomotive.

(Plate VI.)

(*Scale*, $\frac{3}{4}$ *in.*; *gauge*, $3\frac{1}{2}$ *in.*)

The accompanying photograph (fig. 367), and the drawing on Plate VI., illustrate a $\frac{3}{4}$-in. scale model ten-wheeled tank locomotive of ample proportions, and represents in miniature the endeavours of locomotive engineers of to-day to provide the largest and most powerful machine the loading gauge will allow. The model is, in its main features, much the same as that just described (Plate IV., L.N.W.R. tank), except that it is provided with a lagged boiler $3\frac{3}{4}$ in. diameter of the same pattern as that depicted in the photo on page 64, which illustrates a tender engine of exactly similar design and size, and Stephenson's link motion. The frames for this loco are described in Chapter V. (see fig. 55). The driving wheels are $4\frac{7}{8}$-in. diameter.

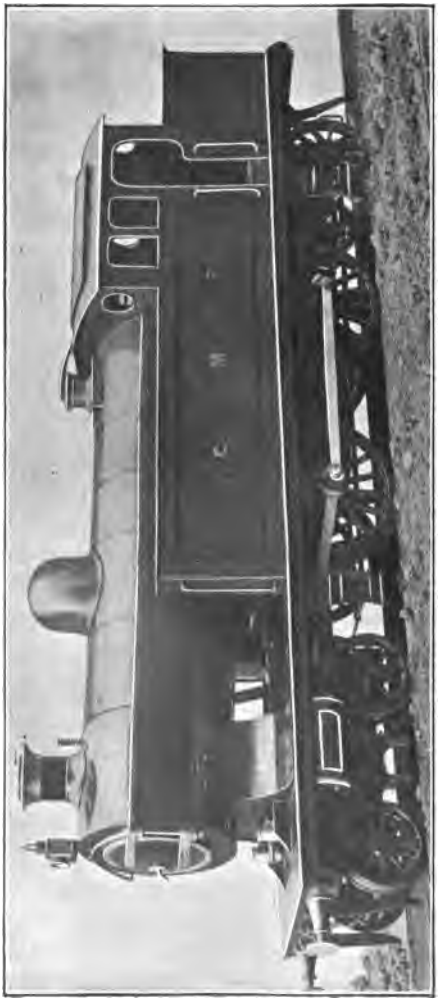


Fig. 367.—A Model $\frac{3}{4}$-in. Scale Tank Locomotive.

The shell of the boiler is $\frac{1}{16}$ in.; and the seams are chain or zigzag, riveted with $\frac{5}{64}$ rivets

at $\frac{3}{8}$-in. pitch. Half-inch cross-water tubes arranged in the form of a baffle are employed. The left-hand half of the bunker is arranged for the water supply, a 'drowned' hand pump being fitted. The tank has a novel discharge valve.

A Model L.T. & S.R. Tank Locomotive. (Plates VIII. and IX.)

(*Scale*, 1 *in.*; *gauge*, $4\frac{3}{16}$ *in.*)

This class of tank engine has long been popular with those who make the study of locomotives—real and model—their hobby, and the L.T. & S.R. engines, being capable of 'express' work, are a very good prototype for the model-locomotive builder.

The difficulty of firing and driving a closed cab model is removed by the use of oil fuel in 'Primus' burners, and by arranging the centre part of the roof of the cab, sufficient to allow of the operation of the various levers, to be taken off. To strengthen this part, and to keep it in position, it is provided with angle 'irons' projecting on the under side; and to facilitate taking it off, that which forms the cab ventilator in the actual locomotive is added. This makes a convenient hand-hold for the loose part of roof.

The cylinders are outside and 1 in. × 2 in. stroke, which gives a tractive force at 50 lb. steam pressure, of 15·4 lb. The completed model will weigh about 80 lb. when finished, and if no great load is to be hauled behind it, this size will be found sufficient to run the engine at a reasonable speed. The cylinders may be bored out to $1\frac{1}{8}$ in. if desired; but this diameter must be considered as the maximum.

The arrangement of steam and exhaust pipes facilitates the removal of the boiler, a point which should always be considered by the model-locomotive designer; nothing is more annoying than to have a trifling leak in the boiler, and to find that its stoppage cannot be made without cutting or unsoldering many parts of the engine. The nozzle of the exhaust pipe is removable; it can be taken off and altered to any desired orifice which experiment may prove to be the best.

The stuffing box for valve spindle must be applied to the valve chest after the cylinders are bolted to the frames. The steam-ports are cast in, and the cover at the front end of valve chest

enables the faces to be milled, and the valve, with its buckle, to be placed in position. The large cover, besides providing for finishing the ports, allows the erector to see the valves during the operation of setting, lightening present labour and saving future trouble.

The centre line of the whole of the motion is horizontal. The piston rod is guided by a single slide bar, the end nearest to the driving axle being brought to a feather edge on the under side to allow the connecting rod to clear it, and is affixed to a lug on a bracket from the main frames; the other end is supported on the cylinder cover. The main frames are of $\frac{3}{32}$-in. mild steel plate, and instead of a radial axlebox a pony truck has been adopted.

The bogie and bogie framing is of the orthodox pattern, and no further description of this seems necessary. The only point which may with advantage be noted is that the model is provided with means of adjusting the weight upon the bogie spring (see page 83, fig. 80). Such adjustment is of great importance, otherwise the model will not work at all well upon the springs, and the appearance will most likely be marred by the footplating and frame not being parallel with the rail when viewed in elevation. The back-plate (*i.e.* the longest plate) of the spring should have a steel bearing pin hard-soldered on to it at the end, and this should rest in a hollow made by drilling a hole right through in the box fork.

The upper part of the box should be drilled and tapped to receive the vertical eye bolt which is pinned to the equalising bar. To adjust, the spring is removed from the box and the fork turned one way or the other, so that the length of the complete hanger is increased or shortened, according to requirements.

The driving and coupled wheels are supported by an equalising bar between them. The hangers are articulated, and are of similar construction to that used for the bogie.

The footplates should be correctly cut to shape from $\frac{1}{16}$-in. steel plate, and may be in two or more pieces, so long as the joints are made to butt to each other in a workmanlike manner. The square piece in front of the smokebox must be made separate, and should be fixed to angle brass, which has been previously riveted to the main frames at the proper level. It seems desirable that the backpiece forming the bottom of the back tank be made separate from the sides, the two side plates coming as far as the

centre line of the trailing coupled wheel. The joint can be made very conveniently at this place, as the plates are only $\frac{1}{2}$ in. wide. The sides will have to be cut to clear the rods, crank pins, etc., and at points where they butt upon the main frames they should be supported by angles riveted to the latter. Over the crosshead a hole must be cut, and a lid, which can be easily removed for oiling and attending to the crosshead and slide bar, fitted to the space.

The diameter of the boiler of the original engine is 4 ft. 6 in., and outside the cleading a trifle short of 5 ft. When settling the outside diameter of the shell this latter figure was taken as the limiting dimension; the absence of telescopic rings, separate firebox sheet, butt strips, and other details which vary the diameter at different points in the length of a large locomotive boiler, enabled the model to have a barrel which is appreciably larger than the scale size. Allowing $\frac{1}{8}$ in. all round for total thickness of cleading sheet and lagging, the diameter of the barrel may be $4\frac{3}{4}$ in. outside.

The longitudinal seam should be chain-riveted at $\frac{3}{8}$ in. pitch, with copper rivets about $\frac{3}{32}$ in. diameter. The wrapper of the firebox will need to be pinched in to pass between the frames, which are 4 in. apart. A clearance of $\frac{1}{16}$ in. must be allowed at this point, which limits the width of the firebox to $3\frac{7}{8}$ in. It must be remembered that the two bottom rows of side stays will have to have countersunk heads.

The inside firebox is shown on the drawings with the upper part swelled out so that the maximum number of tubes may be arranged. The crown is elliptical, and is stayed by a peculiar arrangement of girders and direct stays. The girders which are inside, should first, after filing to a proper shape, be riveted and sweated to the firebox. It will be noted that the central stay of all has for its support at the head the safety-valve boiler seating. This should be turned up solid, and have holes drilled around the stay hole, to allow steam to pass by to the safety-valve columns.

The throat plate is shown joining the inside of the barrel. The front tube plate of the boiler is a casting in gun-metal, and has flanges to take the barrel and the smokebox wrapper plate.

The tubes, nine of which are $\frac{5}{8}$ in. outside diameter, the remaining two being $\frac{3}{4}$ in. outside, are best fixed in the firebox tube plate,

which should be made from *good* brass plate $\frac{1}{8}$ in. in thickness, reduced at the lower part and flanges to $\frac{3}{32}$ in., by screwing with a fine thread chased taper. The water tubes are six in number, and are placed so that they will, with the help of a small plate attached to the tube plate, form an excellent baffle for the flames. The ordinary firebox stays, $\frac{3}{16}$-in. diameter, should have nuts on the inside only. The smokebox presents little difficulty in construction, and needs no detailed description. The joints of the drag plate, front tube plate and wrapper plate should be carefully made, so that the smokebox shall be air-tight. The front plate of smokebox should be countersunk, screwed to an angle riveted to the wrapper, a red lead joint being used.

The regulator is in the dome (see fig. 305, p. 223), the regulator rod being of bronze, and requiring to be set off over firebox, so that it may clear the central stays.

The section of the side tanks can be obtained readily from the drawings; the recesses for the driving and coupled wheel should be noted, and the splashers to hide the trailing wheels in the cab will have to be provided. To the right-hand one of the latter the rack for the reversing lever is attached. The reversing rod has also to be set here, so that it will clear the splasher. To affix the tanks, which should, when communication pipe, etc., are cut adrift, be capable of being lifted, with the cab, bodily from the frames, stout angle brass should be riveted at the bottom of the side sheets, so that the screws may be driven upward through the angle edging into them.

In the real engine the back tank is provided with water as well as coal space. This could not have been arranged in the model without some trouble being necessitated when erecting the engine; and to enable the oil tank to be made as capacious as possible, the water space at this part was dispensed with. The two side tanks are connected by a $\frac{1}{2}$-in. brass pipe, which joins the side tank by a special cast junction screwed by two set-screws to the under side of the tanks. Splashers are shown for the bogie and radial wheels; as these, to some extent, limit the flexibility of the wheel-base, if the railway is laid with curves of less than 20 ft. radius, they may be dispensed with. This detail of construction — as with others which may be modified—depends largely upon the point of

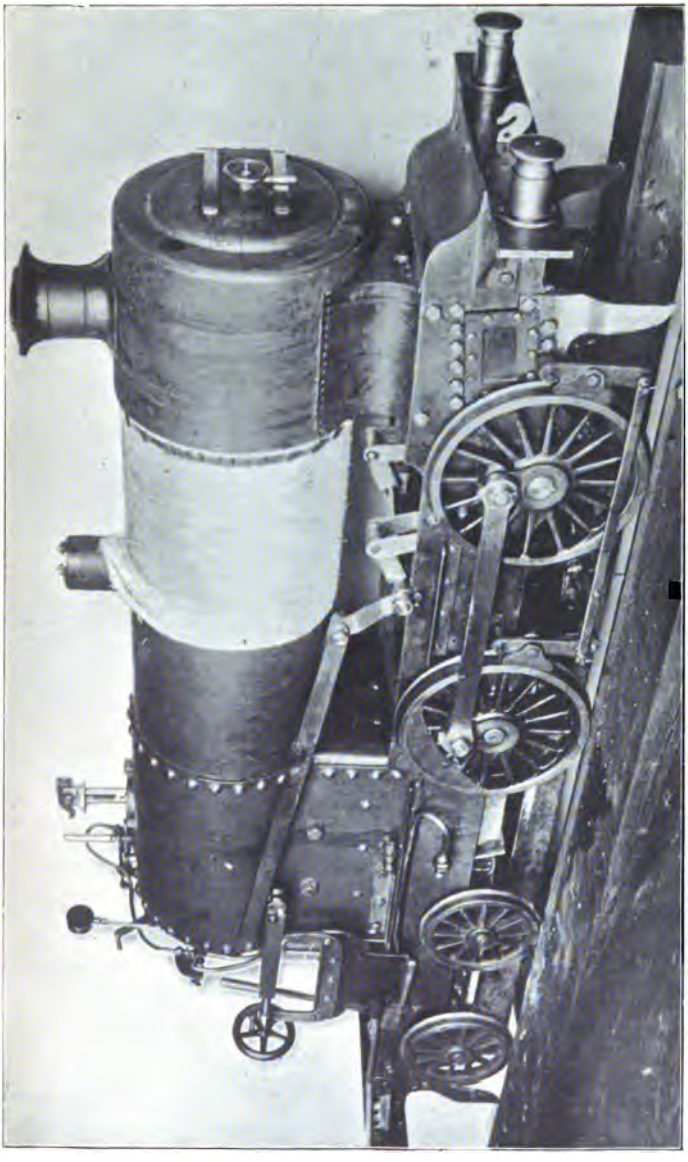


Fig. 368.—The 10½-in. Miniature Locomotive in Course of Construction.

view of the erector. If he requires to keep the external appearance closely to scale, he will retain them; otherwise he will not.

The drawings are all reproduced one-third full size.

A Miniature Tank Locomotive.

(Gauge, 10¼ in.; scale, 2 in.)

On the frontispiece and cover of this volume will be found illustrations of a miniature bogie tank locomotive to a scale of two inches to the foot. This engine has cylinders 2 × 4 in. stroke (see page 113), and was designed, built and in steam in a very short time after it was first thought of. The driving wheels are

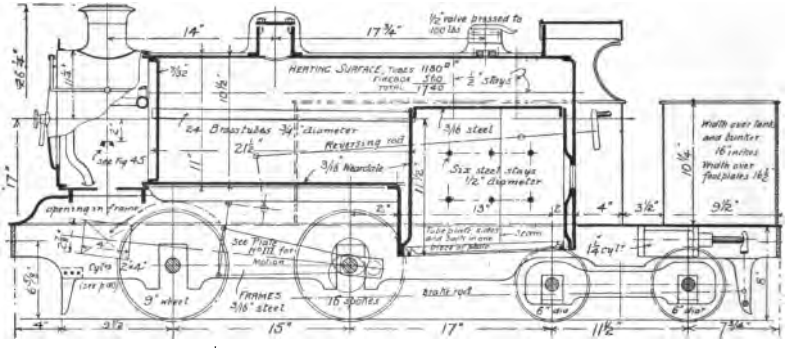


Fig. 369.—A Design for a 10¼-in. Gauge Tank Locomotive.

(Scale, $\frac{1}{16}$ full size.)

9 in. in diameter, the heating surface 1740 square inches, and the grate area 80 square inches. The link motion is detailed in Plate I. The grate is very long, and the boiler of ample diameter. Coal briquettes are used for fuel, and the smokebox arrangements are such that a white-hot fire can be maintained, and at the same time a full head of steam, under all conditions. The working pressure is 110 lb. per square inch. The engine is now in regular service on a 200-yards track, and the writer has repeatedly driven this engine with loads upwards of fifteen adults. The total gross amount the engine will pull is 1½ tons, and the highest speeds fifteen to eighteen miles per hour. A steam brake with a cylinder 1¼ in. diameter is employed, the coupled wheels only being fitted

with blocks. A sight feed and two Roscoe lubricators are employed. For details of this engine, also see figs. 45A, 110, 121, 199, 208, 226, 235, 282, 303, and 313.

An Estate Locomotive. (Plate VIII.)

(*Gauge*, 15 *in.*)

This design embodies the use of a cylindrical firebox and firebox shell. The latter is eccentric with the barrel, to obtain a

Fig. 370.—The 10¼-in. Gauge Tank Locomotive undergoing a Stationary Test.

larger number of flue tubes and to keep the crown as low down as possible. The cylinders should be $3\frac{1}{2} \times 5$ in. and the driving wheels 12 in. in diameter. A radial truck may be employed for the trailing wheel, and if the driver is to sit on the back of the engine, a well should be sunk below the footplate for his feet, and the boiler and cylinders should be thrown forward at the front as shown. Otherwise the boiler may be placed six inches further

back and the wheel-base of the driving and trailing wheels reduced. The design of the firebox renders the use of link motion a simple matter, and the motion may be protected from flying stones and grit by a plate fixed to the frames under the motion and parallel to the surface of the rails. Any of the radial valve gears commonly used for this class of engine may be employed instead of link motion, and the whole of the gear made get-at-able by being placed outside the frames and wheels.

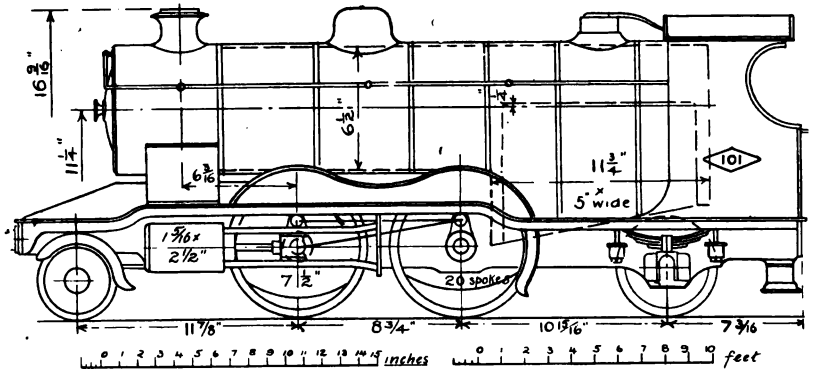


Fig. 371.—A Design for a 1½-in. Scale Model Express Locomotive.

(Advantages of the type—short-coupled wheel-base and long firebox.)

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